ANNALS

OF

The Entomological Society of America

Volume XVIII JUNE, 1925 Number 2

HABROBRACON BREVICORNIS WESM.

By Paul Genieys.*

THE EFFECT OF THE ENVIRONMENT AND THE VARIATIONS WHICH IT PRODUCES.

Action of heat: In the course of my biological study, I have made a number of observations on the influence of heat. The action of this element is so important that I have carried out a series of experiments in order to understand it better. I have submitted the insect in all of its stages of life to the action of temperatures varying from in the neighborhood of zero through freezing to the death point of 46° C., in an air conditioning chamber. According to the stage of the insect, it has reacted in a special way.

In general it may be said that heat provokes and intensifies the activity of the insect. This species acts naturally like all insects having rapid metamorphosis, and has several generations in a year, but while the generations are numerous during the warm season, they are very slow during the rest of the time.

Smits van Burgst† states that a normal period of the generation is twelve days. I observed the following variations according to season:

Rearings in the out-of-doors:

In August	10 to 15 days (Evolution from egg to adult)
September	12 to 16 days
November	17 to 20 days

* Translation from French by Dr. L. O. Howard.

† Smitz van Burgst: Parasieten van het Meelmotje (Ephestia kuhniella Zeller). Tijdschr. Plantenziekten, Wageningen, XXVII, No. 7. Juin 1921, page 77–79.

I do not give here the detailed figures which I have made concerning the larval development, but will note observations on each particular stage.

Action of heat on the adult: Heat acts on the adult as a source of vital energy. We have studied its influence and its effects upon the general activity, including coupling and laying, in the chapter on biology. I will indicate simply certain points. In the laboratory I have noticed at low temperatures absolute immobility; the insect is contracted, the antennæ folded back upon the dorsum and the wings; it remains immobile and scarcely reacts if it is moved. The males die quickly, but the females remain alive for months, but they take no nourishment from the host larvæ and absorb very little liquid, although I have seen this absorption only in the cages and during the hibernating period when the thermometer rises only slightly above 10°. I have never submitted the adult to a lower temperature.

The insect awakens to activity very quickly if one suddenly changes the temperature, and in less than an hour coupling has occurred and the females attack the host larvæ. On the other hand, at a low temperature, 14° to 16° (the springtime average), several days elapse before the hibernating habit entirely disappears. Other things being equal, the longer the repose period has lasted, the slower is the reaction.

The adults can not well stand a heat greater than 43°, at least in the air conditioning chamber. In the outer air with humidity, they stand it better. They may even tolerate a temperature of 55°, 58°, or 60°, but if they are kept in such a temperature, they die in a few hours.

Heat stimulates the appetite; the females often puncture the host larvæ; the males run about in the cages; both absorb moisture with avidity from damp cloths, from sweetened or honeyed water. Pure water does not suffice and the mortality is very great when they have nothing else. Fermented honey, then a little alcohol stimulates them without producing any considerable effect.

Action on oviposition: Oviposition commences at a temperature from 16° to 19°, increases to the maximum at 30° to 38°, and then decreases, and stops at 44°.

Each temperature mentioned seems to bring about a constant number of eggs in the layings. With lots of selected and similar females, I obtained the following results:

Temperature about—

18° to 20°	daily laying	15 to 18 eggs.
22° to 24°	" "	18 to 20 eggs.
28° to 30°	" "	25 to 30 eggs.
34° to 38°	" "	25 to 30 eggs.

While these averages are interesting, in practice it is necessary to obtain the maximum from the best individuals, and also to avoid the too abundant layings which are made by the little adults, and the small layings. A temperature from 18° to 28° (average daily variation) is right for the rearing of *Habrobracon brevicornis* upon the larvæ of *Pyrausta nubilalis* in the fifth and sixth instars.

Action of heat on incubation: This is rather limited; on the average, thirty-five hours elapse between the oviposition and the issuing of the larvæ; at a low temperature the development is most uncertain, and mortality is almost the rule if the hatching occurs after forty-eight hours.

With the elevation the growth is more regular, then more rapid; from 34° to 38° the development takes thirty-two hours, and this is the maximum. Toward a temperature of 40° to 42° irregularity appears again and the mortality increases until from 44° to 45° the mortality is general.

Action of heat on the larval development: As happens with incubation, the larval development does not bear very well extreme temperatures. When submitted to cold, the larva grows slowly; kept at a temperature lower than 14°, it takes five to six days for development. The normal duration is ninety-six hours, and by raising the temperature, this period may be reduced from sixty-eight to seventy-two hours; at 44° trouble begins and the growth becomes irregular.

At these high temperatures the larva often constructs only a rudimentary cocoon or even none at all, and transforms so quickly that the meconium is sometimes badly discharged, bringing about malformations such as clogged wings and legs which will not function. I have also noticed in such rearings males with short antennæ like those of the females, which I will mention in the section on special observations.

Effect of temperature after the formation of the cocoon: The action of the temperature upon the insect when it is enclosed in the cocoon is very important, especially from a practical point of view. It is in this stage especially that the insect stands best the extreme variations.

Cold retarded development greatly, even almost stopping it. As I have no special apparatus at hand, I worked with an ordinary refrigerator where the temperature was held a little above zero, but with variations of some degrees. I have been able to retard the issuing by several weeks. This fact is of great service in the transportation of this species. Enclosed in their cocoons, the motionless creatures are easily handled without danger of wounds, and may be placed in wooden boxes which can be carried in cold apartments for very great distances.

Heat hastens the transformations; normally the insect issues in eight to fifteen days, but if one submits the air chamber to a constant temperature of 40°, the duration is reduced to five to six days. The pupæ will stand 50° for some time, but they will not give out adults at that temperature. In practice, a temperature of from 25° to 30° may be maintained or even less.

Action of heat on the coloration of the adults:* The action of heat on the coloration of the adults of *Habrobracon brevicornis* is very remarkable. In Volume 4 of the species of European Hymenoptera by André, Marshall points out slight variations in coloration. In his description of the male he says: "Facial black spot sometimes reduced to a simple, transverse line, or the head is black with the orbits and the cheeks testaceous. * * * Scutellum sometimes black with the lateral borders testaceous, or entirely black." Slight variations in the abdomen are also pointed out, but without particulars; and nothing is said of the female.

The diversity of colors met with in the specimens which we have from the different regions of France is considerable; these specimens were all collected under the same conditions in cornstalks on *Pyrausta nubilalis*.

The adults collected in the Jura have a black ground color with some portions testaceous, the spots of the thorax very reduced and the scutellum scarcely bordered; on the lobes of

* P. Genieys—Sur le déterminisme des variations de la coloration chez un Hyménoptère parasite. C. R. Société Biologie, Tome LXXXVI, p. 762.

the mesoscutum narrow bands reach quite to the anterior border; the plates of the abdominal segments are very dark with a narrow border on the sides; the face is obscure with only the cheeks and the orbits light. The specimens coming from the region of the Southwest are less fixed; some specimens have broader spots; the ground coloring is brown, the head light. In the South of Provence the general aspect is quite different, and the insect appears lighter at the first glance. Examination shows strong differences among the individuals; the black plates of the first segments of the abdomen are more or less extended; with certain males they are even absent, and the first two segments are white; on the thorax the larger spots give a general impression of smoky brown; the spots on the head are often reduced to an obscure line.

The reared material shows even a greater diversity, greater and more extended differences. With this material we pass the limits met with in nature, which has led me to seek for the causes of these variations.

The action of heat is the most manifest factor, and it acts in an intense way upon the coloration of the adults, bringing about a general depigmentation. But while upon growth the action is continued in the different stages, the color is influenced only in the pupal stage.

The study of pupation shows us the mechanism of the coloration. The eyes are visible after the pronymphal stage, and the ocelli as well; the pigmentation commences on the mesosternum, above the coxæ the surface becomes smoky, the spot spreads quickly in extent and in intensity, while the same phenomenon appears on the mesoscutum and on the stemmaticum between the ocelli, and finally on the scutellum and on the occiput, on the metanotum and the middle of the abdomen. The black color is complete in from 24 to 26 hours; thereafter it is accentuated and the non-colored parts become testaceous, on the mesonotum at first and then on the face and the legs. This is the general process for the parasites which develop regularly in six to eight days in nature and in normal rearings, and in which the rather stable coloration corresponds to the type described by the authors.

Let us consider abnormal rearings, either at, below, or above the ordinary summer temperature. Where the insect is submitted to a low temperature, the coloration comes about in

the order described, but the operation occupies a period of from 20 to 30 days at some degrees above zero. The adult is very black, its head scarcely marked with dark testaceous in a border around the eyes; the thorax is entirely black with two small triangular spots at the base of the lobes of the mesoscutum, another on the scutellum; the legs black with only the extremity of the femora, the four front tibiæ and the tarsi in part lighter; the abdomen black above, the median plate of the first segment only surrounded by an obscure testaceous border, the under side smoky with the corners of the segments black, and the general aspect of the insect is very sombre.

If, on the contrary, we place the specimens in the air chamber with high temperatures, we obtain inverse variations, the normal coloration being less apparent as the temperature becomes higher. With a pupa kept at 40° to 43°, and which transformed in 110 to 120 hours, the black color did not appear at all, and the adult insect was entirely testaceous yellow except the antennæ on the upper side of the two first joints (scape and funicle), an obscure faint smoky or testaceous spot on the mesosternum, two others at the base of the lobes of the mesoscutum, the tegulæ brown, the abdomen yellowish white, with the back light testaceous, and the eyes and the ocelli brownish red. So it may be said that the black coloration of the normal animal has been changed, the lighter parts being distinguished by a yellow testaceous on a reddish testaceous ground. The infuscated part of the wings remains intact, but not so dark.

Between the extremes there is a complete series of intermediary variations. The coloration will differ between individuals under identical conditions in the same experiment. The males seem to be more susceptible to the change; in fact, this is found, according to authors, under ordinary conditions of rearing. But if one raises the pupæ exactly alike, with an equal temperature, no difference is shown. This seems due to the fact that the males develop more quickly than the females and are less exposed to the alternatives of heat and cold and therefore less susceptible to their influence.

Certain portions of the body do not lose the black color readily; notably the stemmaticum, the scape and the funicle, then the mesosternum and the lobes of the mesoscutum, then the lower parts of the sternum and the middle of the dorsal sclerites of the thorax, the occiput, the coxæ, and the middle of the abdominal plates.

In résumé, the production of pigment does not go on with the same intensity in all parts of the body; I have tried to ascertain the reasons for these differences. If we study sections of an adult of average coloration whose black portions are well limited, and which have been reared in the open air in the summer, we will first see that the coloration of the eyes and of the ocelli and the stemmaticum depend upon the presence of pigments in the subcuticular tissue, while with the other colored portions it is the cuticle itself which is pigmented.

In the black portions, aside from the antennæ, of which I shall speak elsewhere, the sections show us that the presence of the pigment corresponds exactly to the muscular insertions. The sections of the thorax shown here demonstrate this especially well. The deposition of pigment stops absolutely beyond these insertions. Thus the large spots on the lateral lobes of the mesonotum are opposite the upper attachments of the large vertical muscles in this region, the lower attachments of the same muscles being in exact relation with the spots of the mesosternum. This is also the case, to cite one instance among many, with the first segment of the trochanter, rich in muscular attachments, while the second segment, where the development of the pigment has been stopped by heat, has almost no such attachments. The case of the antennæ where the basis of the phenomenon is especially difficult to grasp, is a little different. Here the contrast between the coloration of the two first segments on the one hand and the segments of the funicle on the other hand corresponds not to the presence or absence of muscles, but to a very large agglomeration of nervous tissue caused by the sensorial organs which exist on each segment, the scape and the funicle having only simple hairs and not furrows or mirrors.

From these facts we may conclude: First, at the spots where there exists under the cuticle only a simple collection of normal hypodermic cells, the arrest of the pigmentary development is almost complete under the influence of a high temperature; second, in the places where there are added to the usual hypodermic elements, muscular attachments or a massing of nerve elements, the influence of heat upon the genesis of pigment manifests itself in a lesser degree; the intensity of the effect seems to be more or less proportional to the intensity of the cause in both cases.

All things being equal, at least for the cellular units of a determined tissue, it appears allowable to admit equal physiological potentialities, and for the special case with which we are dealing, that the capacity of producing pigment is almost the same for all the hypodermic cells of the body. But if factors intervene whose effect brings about an increasing of the general physiological action in a given cellule or in a group of cellules, there will necessarily result a greater activity in the production of pigment as in all the other cellular functions.

But before the formation of the pigment has taken place, the musculature of the adult is already in place and formed. The muscles then exert a hypodermic traction on the places to which they are attached, and this traction must result in exciting the cells, which produces a greater activity in the production of pigment. In the antennæ the assembling of nerve elements fusing with the hypodermic cells produces in the same way an increase of cellular activity with an excess production of pigment, but in this case the nature of the excitation is more difficult to formulate.

With the individuals reared at a low temperature, the differences which we have just described in the production of pigments in the different parts of the body exist in the same way, but they are less perceptible, since the cuticle is already black above the normal hypodermic cells, the aspect of the regions in which the pigment differs in quantity being identical to our eyes.

When we submit an individual to a high temperature, this evidently acts in the same degree upon all parts of the body so as to increase, so to speak, by a given fraction the production of pigment; but if the action of a given cellule is weak from this point of view, a certain degree of heat will stop it entirely, while in the same conditions of temperature with a neighboring cellule where the physiological activity is greater, the secretion of pigment will only be retarded.

But as we have seen, it is exactly in the regions where muscles are attached or where numerous nerve elements bring about an exceptional physiological activity that the arrest of the pigmentary development is the most difficult to obtain, these places remaining black where the ground color is brown, and dark testaceous where the coloration is light yellowish or light testaceous.

The effect of the heat factor is not permanent in that the variation is limited to the individual and leaves no traces upon its posterity. The eggs of very light females which are reared in a sufficiently cold environment give black adults even if the female is of a third light generation. The descendants of insects of abnormal color seem to have no more aptitude to variation than the others.

Action of humidity: The action of humidity is more difficult to establish; it is not so easy to handle this element as it is to handle heat and light, at least without special apparatus, which I have not been able to get. In the refrigerator the cold was obtained by putting in ice, and I have not been able to study the effect of dryness, but in the air chamber I have obtained different atmospheres.

I have reared the insects in cages of different kinds: tubes or lamp shades open at both ends, with a closed opening or a net which allows the air to circulate. I have not noted any differences between insects reared in this way and rearing in little glass tubes, the opening of which is corked by a compressed wad.

The only action due to humidity is shown at a high temperature. I have raised some families in the air chamber at 38° to 40° in a saturated atmosphere. To do this, I placed in the air chamber a large glass dish with water, closed above by a glass plate, and in its interior I put another little glass dish covered with water.

The egg deposition of the females kept in this atmosphere has been exactly the same as that obtained in the dry air chamber at the same temperature. To keep the insect from drowning itself, I have enclosed it in a little glass box with a loose cover, the box placed in the glass dish, but to increase the saturation I put in a little wad saturated with water with the animal.

The eggs and the larvæ are developed parallel to those in the air chamber, no more quickly, but there was a great mortality in the transformation of pupæ; a remarkable point is the general absence of the cocoon, all the larvæ which rest upon the glass walls transforming naked, but this change of habit brings about serious troubles, and the mortality is extremely high. A little bit of cardboard or elder pith in the tube brings about the construction of a cocoon, and in contact with either of these the larva spins as usual, perhaps because these substances absorb the humidity.

The most remarkable effect is the action on the coloration, which completes the action of heat. The adults coming from this rearing are of a very light testaceous, almost yellow, with the spots above the muscular insertions faint.

The rearings under humid conditions have not given good results, for in addition to the difficulty of carrying on the operations, fungi attack the host larvæ and the parasite larvæ, killing them.

Action of light: Light is indispensable to the adults, at least for the females at the beginning of their life as such. We have studied its action on coupling. The males do not like obscurity, but the females prefer it. I have seen egg laying in absolute obscurity; in the tight boxes in which they have attacked the caterpillars, have paralyzed them, and have laid their eggs like their neighbors in the light, I see no differences; the proportion of the insects killed by the larvæ is only a little greater.

Incubation and the larval and pupal development are the same in the light or in the dark. I have also experimented with white, yellow and red electric lights without results.

Action of nutrition: I have tried *Habrobracon brevicornis* with different elements with varied effects. Artificial nourishment has not given good results; provided abundantly with water sugared or mixed with honey, the males live well and couple effectively, but it is quite different with the females. Without doubt such food keeps them in good condition for a long time during the period of repose, in the winter, and that is almost the only nourishment they take, their torpor being too great to allow them to attack and paralyze the caterpillars, if food is insufficient to give them the energy for vital actions.

In from 20 to 25 days in the summer an insect, although it has lived in the midst of an abundance of nutrition, languishes, becomes less active, and dies. If one puts a female on a paralyzed caterpillar ready to receive the eggs, it is necessary to wait a day or two before the eggs are laid, while the adult parasite feeds, absorbing a little juice from the body of the victim, as if that were necessary for the maturation of eggs.

If one takes a female quickly after the first laying and feeds her anew on the artificial moisture, and then replaces her with the host larva, a new egg-laying will take place only after a new meal of nourishment from the host, as in the former case, but

the insect will not last long in this way, and after two or three operations of the kind, it dies.

(I have not done much with the artificial nourishment of the larva, but the little I have done gave totally negative results. I am going to begin a new series of experiments.)

Pantel states that the health or reverse of the host is a factor which influences the larval development of Dipterous parasites. In support of this statement, he cites the case of *Tachina V.*, which very appreciably increases in rapidity of maturation when the larva of *Chondrostega* which it inhabits is badly nourished. This fact appears to be general with species which pass only one stage of flesh-feeding.

I have observed quite another effect with the larvæ of *H. brevicornis;* when the caterpillar of *Pyrausta* which carries the eggs decomposes very quickly, most of the larvæ die, some, however, arriving at maturity, but not without trouble, and their larval development is notably prolonged. Perhaps a great quantity of nourishment compensates for a mediocre quality.

For example, among the rearings in the air chamber at from 34° to 42° I have obtained:

	Duration of Larval Stage	Duration of Nymphal Stage	Total Duration of Development
Normal rearing 599—34—A	3 days	6 days	9 days
Normal rearing 599—34—A—7	4 days	7 days	11 days
599—35—B—7.....	4 days	8 days	12 days
599—35—B—1.....	5 days	8 days	13 days

Pantel also says that the evolution is slower when there are few commensals; for my part, I have never noticed differences in groups which may be more or less numerous except that when there were many larvæ, the last ones issuing find very little nourishment, and they search for more for quite a long time before making their cocoons. The development is prolonged in this way one or two days and sometimes more.

Habrobracon brevicornis is not a specific parasite of the corn *Pyralis*; the literature gives a number of other hosts. I have tried to complete my observations by giving to the female

several different larvæ, and according to the species I have been more or less successful.

Dioryctria abietella Zinck. or *Phycis abietella* Zk. (Pyralidæ). This is the *Pyralis* of pine cones (on *Epicia*, fir tree, pine trees growing wild and along the coast).[1] Marshall[2] cites *Habrobracon brevicornis* as a parasite of the larva of this species in England and Belgium, De Gaulle[3] in France.

Myelois ceratoniæ Z. Is. 1839 (Pyralidæ), caterpillar parasitized in England and Belgium, according to Marshall.

Ephestia kuehniella Zell. (Pyralidæ), the Mediterranean meal worm. This cosmopolitan larva lives in meal and flour and is found all through the year in mills and storehouses, and appears to be the preferred host of *Habrobracon brevicornis*,* or at least it is the best known host. Marshall mentions a flour mill in England where he has found the parasite visiting the infested mill contents by myriads. This author has also found the insect in Belgium; Smits van Burgst mentions it in Holland, and De Gaulle in France.

Ephestia elutella Hüb. (Pyralidæ), whose larva is found in houses on bread, dried plants, dried fruits, etc., is equally cited by Marshall as host in England and Belgium, and De Gaulle in France.

Galleria mellonella L. or *cerella* Fabr. and *Galleria grisella* Fabr. or *alvearia* Dup. (Pyralidæ), whose larvæ are well known to bee culturists, is also parasitized by this species in France, according to De Gaulle.

Grapholitha rufillana Stainton, or *gallicana* Cyn. (Tortricidæ). A little larva which lives in the umbels of the wild carrot (*Daucus carota*). Chrétien has collected *Habrobracon brevicornis* on this larva at Nanterre (Seine et Oise). I have reared the parasite from a little caterpillar which also lives in the umbels of the carrot, namely, *Hypotia corticalis*.

Diatræa zeacolella Fabr. (Noctuidæ) lives in the lower portions of cornstalks and causes important injury in the United States. *Habrobracon brevicornis* has been reared from it with success.

---

[1] A. Barley: Traite d'Entomologie Forestière.

[2] Marshall: Species des Hyménoptères d'Europe et d'Algérie.

[3] De Gaulle: Catalogue.

* This is *Habrobracon juglandis* Ashm. (R. & C.).

Sesamia nonagrioides (Noctuidæ). Like the preceding, this is a large caterpillar which lives in cornstalks and which we have often found in the Southwest of France, occurring also in Portugal and Algeria, although in certain years (1922 in Gers) it did not do very great damage. The frost, as a matter of fact, killed all the partly grown larvæ and only the small ones which passed the winter succeeded in multiplying. This caterpillar is rather large and little more than three centimeters long; its skin is tender, smooth, and slightly rosy. The female *Habrobracon* attacks it vigorously and paralyzes it in a short time, laying her eggs on the back, and the larvæ develop quickly and well. In a rearing I put in one cage six females of the parasite and two larvæ of the *Sesamia;* I kept the air chamber at from 25° to 28°; twelve days afterward I had sixty-two adults (thirty-seven males and nine males having issued and sixteen still in the cocoon); the caterpillars were not entirely empty, but a little decomposed, and from the decomposition they had died. I multiplied the rearings on this host always with success. In nature I never found *Sesamia* parasitized.

Leucania zeæ (Noctuidæ). A good sized larva (2 to 2.5 cm.) which lives on corn, but on the exterior. I have often tried rearing this parasite on this species. The female stings and paralyzes the larva, but only the large caterpillars resist the puncture and do not die immediately. The parasite then lays its eggs, which develop very well. In a rearing November 26, 1922, in the air chamber at about from 32° to 34°, I placed two female parasites with one of the Noctuid larva collected in the sheath of a corn leaf; paralysis occurred quickly and twenty-seven eggs were laid during the following night. Ten days afterwards twenty-seven males issued from their cocoons, but they were small and they had exhausted all the nourishment in the body of the host larva.

Phthorimæa operculella Zell. (Tineidæ). The potato tuber moth. The small larva lives in the interior of galleries in the leaves and in the tubers. Imported into Provence, it caused some damage in fields, and its essential parasite is *Habrobracon johansenni*, which has been purposely introduced from America. But while this insect usually attacks the caterpillars in their cocoon before their transformation to a chrysalis, the females of *Habrobracon brevicornis* pierce the larvæ only before the formation of the cocoon, paralyzing them, feeding, and ovipositing

very well. I have been able to rear as many as ten parasite larvæ upon one host larva. This was evidently too many, since the adults obtained were small. This host larva therefore is not well suited to *brevicornis*, and many of them die without permitting the parasite larvæ to reach their full development.

Acrobasis obliqua (on buds of the rock rose). This green caterpillar, more or less obviously striped with red, is very abundant on the hills around the city of Hyères in April, May and June. It lives in the buds of *Cistus albidis*, which it eats out and destroys. The female of *Habrobracon brevicornis*, put in the presence of this larva, attacks it quickly and paralyzes it. I have noted the first puncture ten minutes after the introduction of the parasite. The oviposition is abundant; in fact, too abundant, for the host larva can not nourish more than seven individuals, although the larvæ develop quickly and very well. It is a species that is very good for rearing purposes and good results always follow.

Tortrix viridana L. (Tortricidæ). This larva ravages the foliage of oak from May to June, is very abundant and easy to get, since it spins down from the leaves suspended by a silken thread, and may be captured while doing this. The *Habrobracon* easily parasitizes this species, and the parasites are easily reared. In one case six hours after coupling the host was paralyzed and the female parasite laid five eggs.

I have also secured the parasitizing of another caterpillar which feeds upon the oak, but which has not been identified. It is a large pale green species. It was quickly paralyzed and oviposition was quite numerous, the female parasite taking much nourishment from the puncture hole.

Nothris senticella Stegr. (Gelechiidæ). A species which feeds upon *Juniperus phœnicea*. This is a little, dark green caterpillar, the color of the plant upon which it lives enclosed in a little case. I have had good results with this species, which is easily parasitized, although one of them supports only a small number of parasitic larvæ.

A spinning larva which lives in a case on the leaves of pear proves to be an interesting host, but here death and dessication occurred too soon to permit all the larvæ to complete their development.

On the other hand, I have tried, always in vain, to make this species parasitize the larvæ of Geometridæ. I have col-

lected upon oaks, among others, large black and green larvæ, and have put them in little rearing cages with females of *Habrobracon*. I have never noted any stinging; the females ran about without paying any attention to the larvæ, which immediately waved themselves about like little branches. After some days the exhausted females died of hunger.

Liparis dispar L. (Lymantriidæ). The gipsy moth. With this famous enemy of oaks I have had greater success. With numerous experiments the female readily punctured this caterpillar and then searched among the bristles for a point where the skin was naked, and then perforated the body for a sucking hole. Only the large larvæ were able to stand the puncture and especially the sucking of nourishment. The others died in a few hours and dried up. Upon those of the larger stages which resisted, the female deposited eggs, but they were almost always attached to the hairs. Hatching took place normally and the young larvæ crawled on the bristles; descending and finding themselves in the center of the tuft, they mounted another bristle and reaching the top, descended again, keeping on doing this until they were exhausted, when they remained quiet, contracted, and died. So it is that in spite of the quite abundant ovipositions which I got on these larvæ, I have never seen a larva which fixed itself and developed. Once I took some larvæ from the hairs and transferred them to the lower surface of the host larva. Some of them commenced to feed, but the host larva died and all perished.

Pieris brassicæ L. (Papilionidæ). Cabbage butterfly. After this experience with a bristly host larva, I sought for a caterpillar whose skin should be much more accessible to the parasite larvæ. I put large *Pieris* larvæ with the females, obtained the paralysis, and the females fed with a good appetite, with the result that the abdomen became greenish. However, the host larva did not withstand the puncture, threw out a brownish material, and died very quickly. The next day it was flaccid and dead; in three days it was entirely dry. I never saw any egg laying by the parasite, and therefore was not able to rear any larvæ.

Aporia cratægi L. (Papilionidæ). This brown Pierid larva, closely related to the preceding, was easily found on the wild pear and the hawthorn. The female of *Habrobracon brevicornis* punctured it, paralyzed it, and fed upon it (the abdomen here

becoming black), but the larva did not die so quickly. The ovipositions were not numerous and the larva developed, but not very well, taking more time than usual. In one rearing a female laid its eggs upon the larva, which it had just parasitized, but some hours afterward a whole family of *Apanteles glomeratus* came out from its body. In spite of this fact, it did not die very quickly and some larvæ of the *Habrobracon* finished their evolution.

It plainly results from this study that *Habrobracon brevicornis* is a polyphagous parasite, but nevertheless its polyphagy is confined to certain groups. It is essentially a parasite of Lepidopterous larvæ with naked skin and sedentary life. Exceptionally it may be reared from more active caterpillars which are external feeders, as the corn Noctuid, the oak spinner, etc., but in general it attacks insects in galleries either in the interior of the plant (*Sesamia*, the corn Pyralid, etc.), (or especially on stored vegetable material (the larva of the meal moth, the bee moth, the potato tuber moth, etc.).

The Noctuidæ furnish some hosts, but the preferred victims are Pyralidæ and Tortricids. Larvæ whose bodies are covered with hairs are objectionable to the parasite larvæ, which reach the skin only very rarely. The less protected Papilionidæ are often attacked and are very sensitive to the punctures of the female parasite, but they die very quickly.

Marshall has also reared *Habrobracon brevicornis* from the galls of *Andricus* or *Cynips terminalis* Fabr. C. Houard has also described this rounded or ovoid gall which has no roughnesses, but is usually marked by depressions; its color is mixed yellowish and reddish, and its size varies from that of a walnut to that of a small apple. A cross-section shows several ovoid cavities whose great axis is parallel to the branch at the extremity of which the gall is attached.

Commonly called oak apple, it is found upon several varieties of oak and appears in the springtime, often before the leaves. It dries up at the end of July and in August.

It is hardly probable that *Habrobracon brevicornis* parasitizes Cynipids; its ovipositor is too feeble to reach the insect lodged in a cellule whose wall is formed of a rather hard substance and the insect itself is surrounded by a spongy tissue. Moreover, we have seen in our biological study that the female never attacks caterpillars in a cocoon, and therefore there is much more reason to believe that it would not attack one in a cell like this.

But with the Cynipid there live numerous commensals, particularly Lepidoptera, namely: *Lithosia complana* L. (Noctuinæ); *Phthoroblastis motacillana* Z.; *Phthoroblastis costipunctana* Hw. or *gallicolana* Z.; *Steganoptycha corticana* H.; *Penthina profundana* Sv. (Tortricinæ). Evidently it is the Lepidoptera which are parasitized; this is also the opinion of J. J. Kieffer, as he has stated in his "Monograph of the Cynipids of Europe and Algeria."

We also find in the galleries larvæ of Diptera, Hymenoptera, and Coleoptera. I do not believe that this parasite attacks them. I make no assurance in regard to the Dipterous *Clinodiplosis biorhizæ* Kieff., for I have not tried any rearings upon the larvæ of Diptera, but only on the pupæ of flesh flies from which I have no results.

As to Hymenoptera, Proctotrupids and Cynipids are protected by an envelope; as for the Chalcids, Ichneumonids and Braconids, I have never obtained this species as a secondary parasite, but I have tried to rear it upon the false caterpillars of the Tenthredinids collected upon the leaves of oak. The females have punctured them and paralyzed them and have fed at the puncture holes, but have not laid eggs, and the Tenthredinid larva dies immediately and dries up after the puncture.

I have also studied the case with Coleoptera; I have not been able to find *Balaninus villosus* F., which lives in this gall, but I have tried it with a neighboring insect, namely, *Balaninus elephas* Gyll. and *B. glandium* Marsh. The female parasites were entirely indifferent to these larvæ, which they did not seem to notice and never tried to puncture. They finally died of exhaustion.

Another Coleopterous larva, a Cerambycid (*Saperda populnea* L.) taken from a poplar twig, did not tempt the female *Habrobracon*. One was killed by the Coleopterous larva after four days, and another died exhausted after eleven days without having tried to nourish itself.

On the contrary, in an acorn excavated by the Balaninus was a Tortricid larva (*Carpocapsa splendana* Tr.); the female *Habrobracon* punctured it at the first contact, six hours later had already deposited seven eggs upon the paralyzed caterpillar, and the next day ten, but the victim was not able to nourish this number and only three adults issued.

On the subject of nourishment I may add some other experiments. I transported the larvæ of *Habrobracon brevicornis* from one caterpillar to another, from a larva of *Pyrausta nubilalis* paralyzed by a female to another specimen, and had some results. The larvæ fixed themselves and fed, but only a small proportion of them. The others contracted and died. If, in place of a paralyzed larva, one which has been dropped in hot water is substituted in very good condition, the parasite larvæ die without becoming attached. Taken from a *Pyrausta* larva and placed on another species, like that of the potato tuber moth, also paralyzed by a female, the rearing is very difficult, but the result is not absolutely negative. If one takes the eggs before they hatch and places them on a selected host paralyzed by the females, the rearing goes on exactly as if the eggs had been placed there by the females. I have tried this several times with success on the larvæ of the potato tuber moth.

I have examined the adults coming from the rearings upon different hosts and have compared them with those obtained from *Pyrausta nubilalis*, and have not noticed any fundamental differences due to change of nourishment, aside from the modifications of size due solely to the quantity of nutritive matter furnished by the host.

BIOLOGY.

Method of issuing from the cocoon: When the animal completely disengages itself from its pupal skin, it rests motionless for a long time, its tissues extremely soft and the wings colorless. Little by little its strength increases, its movements become more active and stronger, and the wings take on color.

The adults move now by jerking their legs and head, moving about in the cocoon. The wings become entirely spread and the creature is in its normal perfect condition. The abdomen, still distended, evacuates the meconium, and the excrement in the form of little ovoid, more or less yellowish balls. Then the mandibles become active, commencing to attack the wall of the cocoon, cutting the silk, thus making several rough holes. But the work is not continuous and the insect often rests, especially at the start, reversing its position. Finally it strongly attacks a certain point near the end where its mouth is at the moment, and makes a round hole which is quite large and definite. It does this patiently and methodically in spite of its haste to issue.

Then the head is easily put out, the antennæ move more actively, are disengaged and pass outside, the work of the mandibles ceases, the insect feels itself free, stops an instant motionless, and then comes out completely by the help of its legs.

This operation varies in duration; the minimum time occupied is an hour, but it may be considerably prolonged. In general the adult comes out during the warm hours of the day, principally in the morning, more rarely in the evening toward the approach of night.

Length of Time Between Issuing and Coupling.

Coupling.—Coupling takes place shortly after the issuing from the cocoon. When the insect is free it goes toward the sunlight, dries itself and smoothes itself and makes more or less free and active motions. When first out of the cocoon the sexes are indifferent to each other, but after a certain time (some hours in summer) the males commence to show signs of excitement. They rub their wings in contact with the females, run after them, and pursue them, shortly afterwards trying to couple. Still inexpert, they are in general easily repulsed. However, in summer, some hours afterwards they couple in the sunlight.

The females seem to be longer in acquiring the aptitude for coupling after issuing from the cocoon. They passively accept the male, turning the antennæ back and lowering the end of the body and moving the abdomen a little; but at the end of September, at 8 o'clock, in the sun, with a high temperature, their resistance relaxes and they accept the male. In general, after a dozen hours and until the end of their life they can couple at any moment whatever.

Coupling occurs with the females only once. The males, however, are able to serve a certain number of females even successively at short intervals. When the female is fertilized she repulses all other males, defending herself with blows of the legs and by a movement of the hinder limbs analogous to that which she executes by beating her wings and lowering the ovipositor by a slight curving of the abdomen.

The coupling takes place by preference in the sun or in a bright light, almost never in dark weather, but it is easily brought about before a strong electric lamp, say of one hundred candle-power, which gives out a strong light and appreciable

heat. When a virgin female meets the palpi or antennæ of a male she becomes motionless, crouches upon her legs, and rests passive without provoking the act. The male, on the contrary, is continually searching for the female. If he touches her he manifests his feelings immediately by a great play of the antennæ and by beating of wings, precipitates himself upon her and moves the wings and antennæ very rapidly. Perched upon her back, the strokes of the antennæ form a right angle to the longitudinal axis of the body, their extremity recurved. Then he bends his abdomen and tries to intrude his copulatory organs. The female facilitates this operation by raising her ovipositor. When the coupling comes about, the movements of the wings stop but the male continues to gently stroke the female alternately with one or the other antenna.

The duration of the coupling is at least ten to fifteen seconds, after which the female walks away without any longer being occupied with anything, leaving the male fallen down. Often he is on his back, moving his legs above him, dragged for a certain distance before he can disengage his organs. Once free, he rehabilitates himself, remains motionless for two or three seconds, and begins to make his toilet, smoothing his antennæ and then his other organs, and is once more active.

The male does not seem to notice the presence of the female for more than a short distance. In the rearing tubes, he manifests his feelings at not more than two or three centimeters, very rarely at a greater distance. More often it is the actual contact of the antennæ which alone provokes excitation. The female, after coupling, runs aimlessly, the ovipositor elevated for some instants, about a minute, and one sees below, on the next to the last segment, the hollow of the pouch where the copulatory organs are placed. After coming to a stop and a slight toilet, everything is all right. After this moment the female obstinately refuses all contact with the other sex. Every attempt is useless. If a male approaches she becomes immovable. If he makes an attempt she defends herself with her legs and moves her abdomen to put out the ovipositor. I have never been able to obtain a second coupling, even after a long period, by putting females in a small enclosure with a very large number of very active males, when all were repulsed and obliged to give it up.

Duration of time from issuing from the cocoon to egg-laying: The duration of time between the issuing from the cocoon and

egg-laying varies greatly. It is controlled by numerous factors, of which the more typical are temperature and coupling, so that during the summer when the temperature is high and the multiplication is rapid, the non-fertilized females can begin to lay four or five days after issuing. If, on the contrary, the temperature is low, the egg-laying is very much retarded. The insect remains motionless, the antennæ turned backward, crouching upon its legs, somewhat hidden; it sucks little nourishment. Perhaps certain females pass the winter in this way; without being able to affirm this fact, we have, however, kept in the laboratory insects born the end of September quite to the middle of April. In the refrigerator they have the same reaction, resting motionless for a long time and recommencing their activity when environmental conditions become normal.

A second factor which retards oviposition, everything else being equal, is coupling. This act has a very characteristic effect, since among several females issuing the same day from the same rearing, the non-fertilized ones commenced to lay on the fourth, fifth, and sixth day, and those fertilized waited from fourteen to eighteen days.

Expt. No.	Date of Issuance from Cocoon	Date of First Egg-laying
Normal temperature of month of September		
Virgin females		
524—8	Sept. 1, 1921	Sept. 3–4, 1921
524–9	Sept. 1	Sept. 3–4
524—17	Sept. 2	Sept. 6–7
524—26B	Sept. 2	Sept. 6–7
Fertilized females		
524—10	Sept. 2	Sept. 20
524—11	Sept. 2	Sept. 8
524—26A	Sept. 2	Sept. 18
Constant temperature of 32°–34° (in air chamber)		
Virgin females		
599—33	Sept. 20–21, 1922	Sept. 24
599—33x	Sept. 20–21	Sept. 23
Fertilized females		
599—34A	Sept. 20–21	Sept. 27
599—34B	Sept. 20–21	Sept. 27

Total duration of the period of oviposition: This varies in the rearings between rather narrow limits. It is about one month, in general, at the normal temperature, but if the temperature lowers, the laying is slowed down and its duration is prolonged, in September and October at about 16° to 20° C.; at least I have obtained a period of 48 days.

State of Female	Exp. No.	Total No. of Eggs	Duration of Period	Duration of Life
Rearings in open air				
Virgin	524—8	16	26 days	33 days
Coupled at end of life	524—10	12	18 days	39 days
Coupled	524—11	22	38 days	47 days
Coupled	524—17	9	14 days	20 days
Coupled	524—26A	9	17 days	38 days
Coupled at 5th egg-laying	524—26B	26	37 days	43 days
Rearings in air chamber at 32°-34°				
Coupled	599—34A	21	23 days	32 days
Coupled	599—35A	9	10 days	23 days
Coupled	599-35B	12	14 days	24 days

Numbers 524—8 Virgin *IX 1921	524—11 Coupled IX 1921	524—26B Coupled IX 1921	599—34A Coupled (Rearing in air-chamber) IX 1922
1—19 eggs	2—32 eggs	13—22 eggs	27—15 eggs
8—16 "	8—28 "	14—14 "	28—27 "
12—13 "	11—19 "	15—15 "	29—32 "
13—17 "	12—15 "	17—20 "	30—26 "
14—15 "	13—32 "	18—22 "	1— 9 "
15—20 "	15—34 "	21—15 "	2—10 "
16—13 "	17—20 "	22— 6 "	3—28 "
17— 4 "	18—18 "	23—12 "	4—30 "
18—21 "	20—16 "	24—13 "	5—32 "
19—10 "	23—14 "	25— 3 "	6—36 "
20— 6 "	24—10 "	26—16 "	8—40 "
21— 3 "	25—23 "	27—14 "	9—38 "
23—25 "	26—16 "	28—11 "	10—20 "
25—18 "	27—20 "	29—13 "	11—25 "
27—14 "	29—19 "	30—10 "	12—31 "
28— 5 "	30—17 "	1—14 "	13—30 "
	1—10 "	2— 9 "	14—28 "
	4— 7 "	3—15 "	15—30 "
	8— 8 "	4—25 "	17—20 "
	9—13 "	6— 4 "	18—25 "
	13—15 "	7—10 "	19—15 "
		10—13 "	

* November.

An insect which has commenced to lay can not stand a long stop, and dies rather quickly if the cold persists.

At the beginning of the period the oviposition is more active and the female puts out each day a greater number of eggs. Toward the end the deposits are less numerous and farther apart. In the air chamber in the rearings at a high temperature the layings are more frequent and more abundant and the total period is thus restricted.

Oviposition: Egg-laying being the principal occupation of the insect's life, one would imagine that this act would be conducted with care after an especially careful preparation. The host larva once completely paralyzed, the female sucks nourishment as we have seen, then becomes motionless for a considerable time, poised upon the prey. She then commences to look for the exact spot where she shall lay her eggs. She runs over the whole body a number of times, introducing the ovipositor and the dilated abdomen between the support and the future host. In general, it is the lower side which is chosen but not obligatorily. She thrusts her ovipositor to the bottom and makes it describe a small arc of a circle. The organ is sometimes more or less withdrawn, sometimes totally extracted. * * * This operation is renewed a number of times and often at the same point.

When the exact spot is found, the insect places itself and holds itself solidly on its legs placed against the caterpillar and the support; its abdomen is so dilated that its length is increased by a third; the totally withdrawn ovipositor with the guides at its base, by a slow and regular movement, feels over the surface a last time, then it becomes immobile and one sees the egg descend in the posterior part of the abdomen, which was flabby and swells, then the insect contracts itself and the egg appears on the lower side of the ovipositor like a little viscous liquid upon a glass receptacle. Toward the middle, between the anterior third and the posterior third, a sort of drop forms which is the posterior extremity of the egg. By the movement of the ovipositor, without increasing in volume, in two or three attempts this extremity is carried to the opening of the organ. The contractions of the abdomen continue and the object slides, the egg grows and forms itself. The ovipositor describes an arc of a circle and in two or three seconds the completely formed egg issues, held by its anterior part (that in which will be

found the head of the young larva). After definite orientation, the ovipositor is withdrawn. The insect rests a moment in the same position, then the female either places a new egg, or it slowly withdraws its ovipositor, which is covered by its guides, the abdomen takes its normal appearance, and the insect lifts itself up.

The egg is laid upon the caterpillar along its long axis. However, if there is a mass of several eggs, the position varies according to the displacements which are necessary. Simply placed upon the host without an attaching substance, the eggs are easily detached if one touches the caterpillar, or from any shock.

When more than one is laid, the number varies from three to six, rarely more, and a certain consistency is noticed in the layings made at the same temperature. As each mass represents a single laying, and as in general between each laying the female must nourish itself, one sees a relation between the nourishment absorbed and the number of eggs laid, a relation which varies according to the individual, its size, and its drinking capacity.

The daily laying of a female is very variable. It is a function having too many factors to enable a general mean. In nature the collected females parasitized from four to eight individuals, which appears to me to be the laying of a single day. This is without doubt lower than it occurs in the breeding cages, but one must remember that in the field the insect has to search some time for its victim. In the rearing cage each morning its victim is at hand. It is evident that the number of hosts infested in twenty-four hours is influenced much by the trouble the insect has in the attack and the paralyzing. In my rearings I have almost always used one caterpillar per day and the study which I made leads me to believe that the insect does the same thing in nature.

We have studied the action of the age upon the reproductive activity. The temperature is the most influential factor, and the least variation produces remarkable effects. Below 16° C. laying does not take place; it becomes more and more active in proportion as the temperature rises, and continues up to 34°–38°, then it becomes more capricious and stops between 43° and 44°. In the rearing, in the open air the laying has a very close relation to the state of the atmosphere and its quantity varies with the

daily temperature. In the air chamber at a uniform heat kept constant during several days the average increases.

All the facts studied so far are shown in the following tables:

TABLE I.

REARING 524—153. CONTROL OF DAILY EGG-LAYING.

Females of all ages and all states, virgin or coupled, maintained in the air-chamber at a constant temperature of 31–33 degrees Centigrade.

Nos.	Dates (September–October, 1922)							
	28	29	30	1–2	3	4	5	6
2	11	15	16	43	33	22	17	31
5	0	2	2	Female dead				
6	49	42	39	48	49	37	21	33
8	27	27	33	63	Female dead			
9	11	17	21	61	39	29		
11	3	21	17	36	15	31	41	
12	0	17	10	36	27	37	25	10
13	7	31	17					
14	19	17	16	29	28	30	40	23
15	35	37	33	60	40	44	45	45
16	29	31	23	56	36	24	33	24
17	37	33	25	18	26	25	36	12
19	7	29	27	54	38	22	31	36
20	28		28	35	28	30	30	
22	14	24	28	46				
23	11	27	19	13	18			
25	26	37	35	64	45	18	40	37
26	0	25	22	54	47	44	49	34
27	7	17	18	14				
28	0	0	3	36	29	32	9	
29	28	29	34	50	25	39	42	19
30	26	28	38	51	38	28	36	25
31	2	17	21	46	36	27	31	
32	16	32	28	59				
34	6	5	0	18	12	22	26	
36	24	29	35	46	47	21	30	21
37	27	37	45	53	41	32	34	41
39	9	14	21	48	33	31	33	40
43	21	32	31	62	15			
44	23	27	42	59	35	34		
46	29	28	61	41	44	45	24	14
48	13	20	31	54	30	33	32	26
50	0	14	25	60	40	26	47	39
Daily total	605	757	811	1434	792	763	774	530
Daily Aver.	18.8	23.6	25.4	46.2 2 days	29.4	30.5	33.6	29.5 Dimin. vitality

TABLE II.

REARING 524–153A. CONTROL OF DAILY EGG-LAYING.

Females taken from preceding rearing box (524–153) accompanied by some others which had not been in the air chamber.
Rearing made in the open air in the laboratory.

Nos.	Dates (October, 1922)							
	7	8–9	10	11	12	13	14	15–16
6	15	6	0	0	26	0	14	23
12	0	0	0	0	0	0	4	3
14	0	40	11	0	0	26	10	
15	11	0						
16	3	27	0	6	0	0	12	6
19	0	36	0	18	13	0	6	0
21	7	35	0	11	0			
29	14	16	13	0	1	0		
30	0	17	6					
36	0	32	0					
37	0	30	4	0	15	0	6	11
39	0	36	0					
46	10	0						
48	11	21	1	0	6	0	10	18
50	21	0						
52	0	0	5					
54	0	0	0	4	10	0	8	0
55	0	25	6	0	0	0	15	10
56	0	13	0					
58	0	1	0					
59	0	17	0					
Daily total	92	352	46	39	71	26	85	71
Aver.	11.5	23.4	6.6	9.9	11.8	9.4	11.8	11.8
Atmosphere	M.B.V.	C.V.S.	M.V.S.	C.V.	C.S.	C.S.	C.S.	S.V.

M: Mediocre weather. B: Foggy weather. V: Wind (always a little fresh). C: Warm fine weather. S: Sun.

In general the females lay their eggs between the body of the caterpillar and the supporting substance, but this rule is not absolute and numerous exceptions are noted. In the rearing tubes the layings may be found on the disengaged part of the victim, and if a paralyzed host larva in good condition is suspended by a thread in the middle of the cage, the parasite will place its eggs, but seemingly regretfully and in small number.

The female lays on all paralyzed caterpillars, even when paralyzed by another insect, but it never lays any on dead prey, even if very fresh. This is shown by substituting for the paralyzed prey upon which the animal was about to lay its eggs,

a caterpillar killed very quickly in hot water and afterwards passed through cold water in order to preserve all its suppleness without coagulating the blood, and the oviposition immediately stops.

When one disturbs a female about to accomplish the act of laying, as the egg has migrated into the extremity of the abdomen, the animal stops and assumes a normal position on its feet, and even makes a few steps, but the abdomen is deformed, the ovipositor lowered, and some seconds afterwards the egg is extruded without precautions.

Influence of nourishment upon the development of the larva: The amount of nourishment which the larva had has a great influence on its size and development, as is shown by the very appreciable differences between different rearings, and even between the individuals of the same family, according as the laying has been more or less abundant, or as the caterpillar offers a varying amount of animal nutrition.

When a female has oviposited on a small larva (stage IV of *Pyrausta nubilalis* for example), and which is rather rare, the victim dies quickly and the parasite larvæ have no time to develop, and perish. The same thing happens with the young of stage V, upon which, however, the laying is less rare. On the contrary, in stage V of the average size, in which the reserve tissues are commencing to be more abundant, the small layings (less than ten eggs) develop rather well. If the number of mouths to be fed is greater, the host succumbs too quickly to permit the majority of the parasites to reach the adult stage, but in the case of old caterpillars of stage V and those of Stage VI, the parasite finds enough subsistence for its eggs to produce perfect adults.

The average families which develop with the greatest maximum are those which comprise 18 to 20 individuals. The caterpillar is entirely deprived of its reserve tissues, the viscera are in part respected, the skin is flaccid, but not entirely transparent. The parasite larvæ are in this case strong and of a clear, handsome appearance and healthy, forming white cocoons and ejecting little larval excrement. They make pupæ of a maximum size and strong adults, large sized, ardent and active.

The small layings also produce good results. In such cases the larvæ can take all the nourishment they wish since it is more abundant than is necessary, both in quality and quantity.

It is quite otherwise with abundant layings. Here the parasite larvæ are in contact. Two cases are observed where the eggs are almost all laid at the same time, at very small intervals, the young larvæ then developing almost simultaneously, remaining an equal size and giving forth adults of homogeneous corpulence, and the batch arrives in totality at the adult stage. In the second case, the eggs are laid in several masses at considerable intervals (some hours), the outcome is irregular, the concurrence uneven. Since the struggle is unequal, the larvæ first hatched eat most and arrive at maturity in good condition while the others develop badly or die.

In the large layings, the nourishment which each larva finds is not abundant, but all is utilized, the caterpillar is entirely emptied and is reduced to a transparent skin, all that is absorbable having been devoured. The coloration of the larvæ is less homogeneous, since those that have eaten the most, the first hatched, or the best placed, are lighter, the size is unequal and always less than the normal. The cocoons are more feeble and the adults are small. There is, however, a limit, a minimum below which the insect can not go, where the larvæ are then no longer able to finish their cocoons and die in constructing them, or in giving out meconium, or in transforming to adults that cannot live. In lots of 35, 45, and 50 individuals one may have specimens measuring scarcely 1 mm. in length, that is to say, one-third in normal length, but they are miniatures of the other adults, and absolutely unfit for any reproduction. It appears, however, that the females cannot support this reduction in size as well as the males, since, while one may keep for quite a long time small male individuals reaching exactly 1 mm. in length totally incapable of coupling, I have never seen a single female measuring less than 1.2 mm. Individuals of this size may couple and lay some eggs, but their life is always short. The eggs laid by the dwarfs are a little dry, but of the size of those of the normal females. The daily deposit is very small (5 to 8), but the individuals which come from them are strong and normal. I had from a large paralyzed caterpillar oviposited in by a female of 1.2 mm., five large active males whose average length reached 3 mm.

NOTE 1. The eggs of the females of *Habrobracon brevicornis*, as I have stated in the morphologic study, vary little in size. The eggs of the dwarfs are smallest, but they depart only

slightly from the normal type. I have never observed that there is a general variation in size in relation to the normal type, as Pantel* has stated for the Diptera. This author observed that in certain Tachinidæ, such as *Meigenia floralis*, a parasite of the larvæ of *Crioceris* and of *Colaspidema atrum*, the normal type gives eggs of 600 microns, but certain individuals which come from a very plump larva of a phytophagic beetle (*Timarcha ?*) and thus growing to a larger size, produce eggs of 800 microns.

With *Thrixion halidayanum*, it is the inverse which takes place; the normal type of this parasite of *Leptynia hispanica* Bal. and of *Bacillus gallicus* Charp. gives a dwarf variety with *Leptynia attenuata* Pant.

But the author adds that these variations, at least that of *Meigenia*, seem to have the standing of racial characters and to be transmitted by heredity. On the other hand, it is the case in which numerous individuals of the same species live in the same host and arriving at the end of their evolution, there are always retarded individuals which, for want of nourishment, remain of smaller size; or again, for larvæ living together within hosts which are accidentally incapable of carrying them to the normal size. The imagos are extremely small and these "individual variations are not effective upon reproduction, if the variation is not quantitive, so as to modify the number of genes."

Paralysis of the caterpillar: When a female *Habrobracon brevicornis* meets a caterpillar (if she is ready to lay or is looking for nourishment), she stops, the antennæ held high and slightly bent at their upper third; after an instant of immobility they begin to move, she advances gently, then stops, balances on her legs, and turns the abdomen under the thorax until the ovipositor reaches the head, then attacks, the antennæ moving, the abdomen elongated to a length nearly double the normal, the segments dilated until one sees the intersegmentary band of skin; the ovipositor is pushed out, the guides reach out to its base, and its extremity passes beyond the tip of the antennæ.

The insect may rest for a long time in this position and it does not appear to have an exact idea of the distance which separates it from its prey. I have watched them for several hours, at some millimeters from the caterpillar the female making

* Pantel: Recherches sur les Diptères a larves entomobies. Extrait de la "Cellule," Tome XXVI, Par. I.

great efforts to reach it and to sting it. If the caterpillar advances a little, quickly the parasite flies precipitately; if, on the contrary, it remains quiet, making a silk thread, carrying the head slowly from one side to the other, or if it is motionless, the parasite advances slowly. Its position is modified, the ovipositor is not generally pushed out to its full extent, and the legs are lower. Finally, when the prey is within reach, by quick movement, after a vibration of the antennæ (without touching the adversary), the parasite darts its sting strongly into the body of the victim, which wriggles furiously from the effect of the puncture and the injected venom, while the female parasite prudently withdraws.

Most often the puncture is given near the head, the female attacking from the front, but it may take place at any other point of the body with equal efficacy.

After the puncture the caterpillar struggles strongly, moving energetically from one side to the other; the open jaws try to bite, and it recoils as far as it can. At the end of a variable, but quite short period (1 to 5 minutes) it stops all outer manifestations and begins the work upon which it was engaged at the moment of interruption. However, little by little vigor diminishes, the movements are slower, and the reaction to external stimuli more feeble. Then comes complete immobility, after a time varying from one to several hours.

In general, this condition is not brought about by the first puncture, and the female makes several darts with the ovipositor, rarely leaving a caterpillar once attacked. I have seen varied attacks, either when the female suddenly darts at some point of the body or when the caterpillar presents itself from behind, or when, being overturned, it can not defend itself, the puncture is given very quickly and very strongly, both the victim and the parasite rolling over together.

When the caterpillar commences to become torpid, the female *Habrobracon* becomes more pressing, attacking with insistence and inserting its ovipositor near the head, in general on the ventral side where the skin is more tender, between the chitinous sclerites of the head and of the first segment with *Pyrausta nubilalis*. This puncture is long and deep and is the coup de grace after which the caterpillar is almost motionless.

The effect of the puncture on the caterpillar never passes away. If the dose of the venom is feeble, the animal may move

during several days, but finally becomes more or less numb and the paralysis slowly increases. At other times one portion of the body is more affected than another, but I never saw the complete activity of a punctured animal restored.

Finally I think I ought to state here that if I have noticed female parasites sucking at the puncture hole on an incompletely paralyzed host, but capable of weak movements, I have never seen them deposit eggs on such a specimen.

Incubation of the egg: The incubation of the egg begins immediately after the laying and lasts for a period which varies according to the temperature, in general 35 hours at the normal temperature of evolution (18° to 30° daily variation in summer).

At laying time the egg is very homogeneous over its whole surface. Three hours later one commences to see the yellowish material contract in the interior of the envelope, which detaches itself very completely upon the sides, but it is twelve hours later that a white point appears at the tip. Three hours after the material contracts still more and at the extremities a pouch appears, always complete on the anterior side which will form the head of the young larva. In three hours more one distinguishes the forming stomach; after two more hours the head is visible and the larva seems to be formed. It contracts, a pouch appears at the summit, and this pouch is filled with a slightly refrangible liquid with globules in suspension. In about five hours it reaches its development or a length of about 1.035 mm. At this time the egg has slightly diminished in size.

As soon as segmentation is distinguished, then a slight internal movement is noticed, the mouth opens and the animal absorbs slowly the contents of the pouch above the head, and one can see the globules pass into the oesophagus. The young larva thus increases in size and finally fills up the whole egg. At this moment the tracheæ are clearly visible. Then the larva begins to move, contracting and expanding, and makes the contents move from before backwards, forcing itself to advance in the egg. A little later the antennæ appear, the shell is pierced, and the mouth is active, feeding on the shell and destroying it. All of these phenomena last for a half hour.

The young larva commences to issue from the egg, throwing the shell from before backwards by its movement. The envelope is more and more flaccid and is finally left at the point of the placing of the egg and the young larva departs without touching

it. During the issuing a little viscous liquid is spread without the shell.

Larval life: After hatching, the young larva leaves the egg-shell, crawls on the body of the caterpillar, moving about without orientation, often for quite a long time, then fixes itself and commences to feed (a half to three-fourths of an hour generally after issuing, but often sooner). In the rearing cages if the hatching is near the caterpillar (in the case of an egg which has fallen off, for example), the larva crawls around apparently aimlessly, and attaches itself if it finds a host in the course of its journey, but if it meets with none, at the end of a certain time it becomes motionless, contracts, and dies. If the birth has occurred upon a host in bad condition, a crushed, dry, dead or partly decomposed caterpillar, the larva tries to attach itself but quickly draws away and dies.

Once attached, the larva commences to absorb nourishment and to devour the caterpillar. It fixes itself at any part of the body and not immovably. It can move its position, but only changes when obliged to do so, as for example where two larvæ side by side are hampered in their development, they move apart. They may be removed voluntarily; they fix themselves again without being incommoded. The larvæ maintain themselves by preference on the side of the host which rests against a support, such as a glass dish. If one turns the caterpillar having larvæ on its lower side, thus placing the larvæ on top, the latter do not hesitate to migrate and in a few hours they are again below.

The larvæ quickly increase in size, their growth is very rapid, and in general there are only from 72 to 96 hours between the time of hatching and the time when the full grown larva spins its cocoon. The temperature is not so important here as with the other stages. There are two molts in the larval period, the first one passed rather quickly and the second only a short time before leaving the host. While it is on the victim, the parasite larva does not stop absorbing nourishment, increasing in volume slowly and constantly by an energetic suction. The color becomes darker but is not uniform, varying according to the individuals and depending upon the quantity of nourishment absorbed. With larvæ which live in small numbers upon a well conditioned caterpillar, the color does not change from a light rose. If more numerous larvæ are obliged to destroy the entire

contents of the body of the host, including the internal organs which are not well assimilated, the color is dark rose, which becomes red if decaying tissues are ingested, turning to violaceous on victims in bad condition, which die and whose contents begin to decompose.

When the larva is full grown, either it will have reached the normal full grown size by the absorption of the maximum of nourishment, or a maximum size corresponding to the digestible material which it has been able to get, as in the case of a large number of individuals attached to the same host, where the utilizable volume from the caterpillar deteriorates. The full grown larva leaves the body of the victim, throws out a thread of silk, makes a delicate and widespread network without any plan; several larvæ may simultaneously construct their web in the same place without being bothered; then the larva fixes itself at a point near the middle and commences to surround itself with its cocoon, spinning by a gentle oscillation of the upper part of the body. The time necessary to finish this work does not exceed from 18 to 20 hours, the animal working without stopping, and immediately becoming motionless after finishing.

But although the work of the larva is very active, the internal work of assimilation does not stop; from the beginning there appear in the body of the larva, upon the basic color of the stomach, whitish granulations of reserve tissue which become more and more numerous and soon hide the base color, which turns yellowish.

When this has occurred, the larva finishes its cocoon, then becomes motionless, the non-assimilable material becomes localized in the posterior portion, forming a dark, perfectly visible spot in the middle, and generally 24 hours after the formation of the cocoon (in summer), they are rejected and thrown back of the abdomen upon the lower surface of which they are spread.

The larva by this time has passed into the state of the pronymph; at the point of the first ring after the head the eyes appear; the coloration commences to show on the posterior dorsal part, the ocelli appearing afterward. While the body is forming, a constriction is noticed at the fifth joint and becomes accentuated until the moment when the larva casts its skin and passes into the prepupal condition.

After this, the insect, inert up to this time, moves vigorously, thus rupturing the skin, generally at the head, which is first disengaged, the larval meconium is thrown out, the antennæ, which were folded about the head, stretch out, the other organs gently disengage themselves, the mouth armatures, and then the legs, stretch and the wings as well. By more robust movements and a stronger fluctuation of the internal parts, the abdomen becomes disengaged and with the females the ovipositor is very active. The skin is then flattened against the other excreta with which it soon forms a brown homogeneous mass.

The volume of the insect has lessened with each one of these operations, and the pupa is now at large in its cocoon, installing itself in the middle in a condition of almost complete immobility.

TABLE OF DEVELOPMENT.

	Egg	Larva	Pupa	Total Development
August.....	35 to 40 hours	3 days	5 to 8 days	10 to 15 days
September.....	35 to 40 hours	3 days	8 to 12 days	14 to 16 days
November.....	40 to 48 hours	3 to 4 days	10 to 15 days	17 to 20 days
Air chamber 37°–41°.....	32 to 35 hours	2½ to 3 days	4 to 8 days	7 to 10 days

Transformation goes on very rapidly in the summer, but it may slacken and stop entirely in cold weather—an extremely important item in rearing, since, as we will show in another chapter, it is in this stage that the insect is most susceptible to low temperature. During the summer, between 18° and 24° on the average, the coloration of the eyes comes about very quickly about 48 hours after the throwing out of the meconium, the thorax turns from gray darker and darker to black. After the thorax, the other dark parts of the body change color and 30 to 40 hours later the general coloration is reached (we will study the coloration in a special chapter); all the organs are complete and seem to float under their cuticular envelope. The coloration becomes still more accentuated and becomes normal in 24 to 36 hours; shortly after the immobility ceases, the insect becomes active, moves its limbs and its head, with which it produces an opening in the envelope by the moving of the antennæ, and these are disengaged first by the lower joints. The cuticle slides from the front backwards; after the head, the

front legs come out, disengage the thorax and the extremity of the antennæ with the female, but with the male this waits until the front legs are themselves entirely disengaged. The hinder

TABLE OF LARVAL DEVELOPMENT (524–68)

Exp. No.	Dates		Formation of Cocoon	Ejection of Excreta	Pupation	Color thorax	General Color	Issuance
	of Egg-laying	of Hatching						
1	2	3	4	5	6	7	8	9
Rearings in open air (September–October, 1921).								
524—8	3–4	6	9	11	12–14	15–17	16–18	18–21
524—9	4–5	6	10	12	13	15	16	18–20
524—11	7–8	9–10	13–14		15–16	18–19	19	21–24
524—9A	7	9	12	14	15	18	19	20–24
524—9B	10	13	16	19	20			23–24
524—11A	9	11	15	17	18	20	22	23–26
524—8A	11	13	16	18	19			24–27
524—17	7	9	13	16	17		20	23–26
524—17B	10	12	15	17	18	20	22	23–26
524—11C	12	14	17	19	20			25–26
524—17D	13	15	19	20				27–28
Rearings made in dry air chamber 37°–41° (September–October, 1922)								
599—33X	23	30 to 33 hours after deposition	26	27	18 to 24 hours after ejection of meconium	28		1–3
599—33.X2	26		29	1		3		4–6
599—35A	28		1	3		4		6–7
599—34B	27		30	2		3		5–6
599—35B	28		2	4		6		7–8
599—37	27		30	3		4		5–6
599—34.A3	30		3	6		7		10–12
599—34.A4	1		4	6		8		10–11
599—35.B4	2		5	7				11–12
599—35.B5	3		6	9		10		12–13
599—35.A5	3		6	9		10		12–14
599—34.A6	3		6	9		10		12–14
599—34.A7	4		7	9				11–12
599—35.B6	4		7	9		10		12–13
599—34.A8	5		9	10		11		14–16
599—34A15	13		16	17		19		20–23
599—34A18	17		20	22		23		25–26
Rearings made in humid air chamber 37°–41°								
524—148.D	21		25	26	27	28		29–30
524—152.A	4		7	8	9	11		28
524—148.D	7		11	12	13	14		16
524—152.D	13		16	17	18	19		20–21
524—152F	13		17	19	20			23

legs come out at the same time as the wings and commence immediately to spread. The hinder legs and the movements of the abdomen help to slip off the skin, and with the females this is strongly aided by the ovipositor, which with its guides contracts and pushes forcibly.

After this hard work the insect is entirely disengaged from its pupal skin, which is thrown back into the bottom of the cocoon in a crumpled mass, which the animal presses as far as possible against the wall where the other excreta are found. The wings spread entirely in the cocoon and the animal throws out its internal meconium with the excreta.

Effects of parasitism on the host-life of the adult: The effects of parasitism upon the host include the elements fundamental to the life of the adult. The female *Habrobracon brevicornis* penetrates into the galleries, perforates the accidental parts if there are any, attacks the caterpillars; with the ovipositor serving as a dart, it punctures and paralyzes, as we have shown, then retires and rests motionless, awaiting the effect of the poison. The victim paralyzed, she tries to get as much benefit as possible; fatigued by the struggle, and to restore her forces, she begins to nourish herself. The antennæ reaching forward, curved at the end, tap with little blows, the parasite explores the body of the prey, stops finally, finds a good spot, becomes motionless, cleans her feet, the antennæ always straight, curves her abdomen until the extremity comes up under the thorax, and sticks her ovipositor in the skin. She works slowly, by little blows; the ovipositor slides in its guides, the base of the abdomen, the only portion of the body which is not motionless, gives a movement from above to below, each time forcing the ovipositor more deeply, until it soon disappears entirely. During the operation the antennæ remain in contact with the body of the caterpillar, but motionless, inclined forward. Her work finished, the female lowers the head and the thorax, withdraws the ovipositor quickly, covers it, and raises the abdomen, which takes its normal appearance. Then she moves a little backward and applies her mouth to the puncture hole, the antennæ thrown backward and motionless; only the mouth parts are very active. All the liquid which issues is sucked up but the supply is quickly exhausted, and in a few minutes the sucking is finished. Then the insect begins its movements, the antennæ bent forward, and moving the palpæ very actively and inspecting the surroundings of the place, looking for liquid. Then the insect abandons the spot, withdraws, and makes her toilet. The puncture makes a very exact wound, easily seen, for it has a brown aureole. According to her thirst, the *Habrobracon* makes a certain number of suckings at more or less frequent intervals.

Mr. B. Trouvelot* has studied the mode of feeding of an American Braconid, *Habrobracon johansenni*, imported into France to help the fight against the potato tuber moth (*Phthorimæa operculella* Zell.). He has described this parasite, very close to *H. brevicornis*, as attacking the caterpillars in their cocoon in order to live at their expense, but forming a mucilaginous tube from which to suck the nourishment for some distance. The persistence of this blackish tube, resembling a large hair, allows the identification of caterpillars killed by the parasite.

In most cases *Habrobracon brevicornis* acts quite differently, and for a long time I noticed at the point of penetration of the ovipositor only a brown circle. It is true that the female directly punctures the body of the animal, never in a cocoon or through a simple net. To compare these two parasites exactly one should work under identical conditions. I have used *Habrobracon johansenni* upon unprotected larvæ of the potato tuber moth (before or after the spinning of the cocoon) and on a microlepidopteron living in the dry calices of the flowers of *Lavandula stæchas*. In these cases *Habrobracon johansenni* has taken the nourishment directly from the body of the caterpillar, and there was no formation of any tube. This was also observed by F. Picard†, who mentions it in a note in a paper on the parasites of *Pieris brassicæ*.

In giving these observations in a note to the Societe de Biologie‡, I concluded, in completing the observations of B. Trouvelot, that the formation of the tubes is due to the presence of the cocoon around the attacked larva. But what cause produces this variation with the change in the conditions of the case? Is this a change of instinct in the absence of the cocoon, the parasite not attempting then to produce a tube, or its behavior remaining the same, is not the tube produced on account of mechanical reasons?

Since this publication, in order to complete my observations, I have made more experiments and I have been able to obtain with *Habrobracon brevicornis* under certain conditions an

---

* B. Trouvelot: Comptes rendus de la Société de Biologie, 1921, t. LXXXV, p. 1022.

† F. Picard: Contribution a l'Étude des Parasites de "Pieris brassicae." Bull. Biologique, t. LVI, Par. 1.

‡ P. Genieys: C. R. de la Soc. de Biologie, 1922, t. LXXXVI, p. 829.

aspirating apparatus. At a glance it has not the appearance of an enlarged big hair, but a simple little brownish cone measuring scarcely a half or three-fourths of a millimeter, often less. This prolongs itself in the body of the victim; sometimes the circle disappears, and under the transparent skin one clearly sees a brown spot, which is a mucilaginous tube analogous to that described by B. Trouvelot and of the same origin.

One can quite easily obtain these structures with the females of *brevicornis* on the caterpillars of the corn borer. To bring this about, I have varied the external factors; I had until then studied the insect nourishing itself at the normal time at the warm temperature of the laboratory during its full oviposition activity. I then submitted the female to an unfavorable method of life; for example, I put it in a little tube so as to disturb the laying without stopping its activity, prolonging its association with the caterpillar for several days. The parasite fed, but after several punctures the weakened host gave less nourishment after each operation and the female worked harder, prolonged her action, and formed a tube. A second method of operating consisted in putting a dozen females in with a single caterpillar. All commenced to feed and with a number of them at work, there was soon an abundance of fluid issuing from the caterpillar, but the conditions were abnormal and the movements of the mass disturb the individual tranquility needed for the proper completion of the work.

The first effect of the absorbing of the nourishment is to render the caterpillar flaccid. Sometimes the female has punctured so frequently, either awaiting the period of laying (in the case of fertilized specimens) or to refresh herself after a very considerable deposit of eggs, that the caterpillar becomes so used up that the parasite does not lay and abandons it.

In most cases the female, after her meal, smooths herself, makes her toilet, runs about without losing contact with her victim, from time to time returning to palpate it, and then feels with the ovipositor for a proper laying place. This takes a variable time, probably depending upon the maturity of the eggs, and finally the female decides to oviposit. This operation takes place in the evening, often at night, at least in the rearing cages, where the larvæ are changed every morning, but it may very well be done during the day.

After the laying the female rests for a bit, then (in the morning in the rearing cages, as soon as the sun becomes warm), it seems to abandon its victim and to recover more of its vivacity. It easily attacks other caterpillars which are given to it, paying no more attention to the laying and returning over it only with apparent regret if left in the same cage.

The insect rests in the morning sun and smooths itself with pleasure, absorbs rose water or the noruishment of the breeding cages, runs upon the walls of the cage, flies from one side to another, then, with the increasing heat, seeks a new caterpillar, attacks it, and paralyzes it. The cycle recommences all through the period of laying.

The life of the males is quite different; they pay no attention to the caterpillars, fly in the sunlight looking for females and for nourishment from a little drop of water or nectar; their life is short and they die quickly from exhaustion. In rearing cages well supplied with sugared water they succumb after two or three weeks.

Paralyzed caterpillars live a long time—several days when the temperature is high, but in cool weather they remain in good condition for several weeks. They make no motion and are indifferent to external stimuli. The young larvæ find at their birth fresh tissues to absorb; as they devour their host in 96 hours at the maximum, decomposition has no time to enter. With the victims which have not been entirely destroyed, there may be even a duration of from 3 to 5 days.

Distribution of the sexes: Non-fertilized females have a precocious, irregular and abundant oviposition, but they produce only males. Fertilized females have a retarded oviposition and produce both males and females. The first eggs laid always give out males; in the second laying males are also in the majority, but in the later layings males only represent a small part of those which reach the adult stage. They become abundant again only toward the end of the laying period.

As soon as a female is fertilized, the sexuality of the laying changes and it makes no difference at what epoch of its life, but the effect varies a little. At the beginning of life laying is retarded; later there is no retardation. It happens thus that a female whose period is more than a month gives out in its first layings males, but the descendants develop quickly and a male

of the first laying may mate with its mother, the descendants changing immediately in sex, and the females appear.

The individual action of the male is very interesting, since a female coupling with an old male quite exhausted by a period of more than a week in the refrigerator and kept alive by sugared

TABLE OF REARINGS.

Numbers:

524—8 Virgin Female Issued from Cocoon Sept. 2, 1921. First deposition Sept. 3–4. *Detail of depositions*	524—11 Fertilized Female Issued from Cocoon Sept. 2, 1921. Coupled 3d. First deposition Sept. 7–8	524—10 Fertilized Female Issued from Cocoon Sept. 2, 1921. Coupled Sept. 5 with old male. First deposition 20th.	524—17 Female Coupled End of Life. Issued from Cocoon Sept. 2, 1921. First deposition on 6th. Coupled on 19th.
11 males	32 males	9 males	16 males
16 "	4 " 24 females	21 "	18 "
13 "	1 " 18 "	16 "	16 "
17 "	1 " 31 "	16 "	23 "
15 "	0 " 34 "	4 "	63 "
20 "	3 " 17 "	5 "	21 "
13 "	1 " 17 "	4 "	36 "
4 "	3 " 4 "	10 "	23 "
21 "	7 " 7 "	18 "	22 "
10 "	0 " 10 "	22 "	7 " 8 females
6 "	4 " 19 "	19 " 1 female	
3 "	1 " 15 "		
25 "	2 " 18 "		
18 "	16 " 3 "		
14 "	0 " 17 "		
5 "	6 " 4 "		
	7 "		
	8 "		
	13 "		
	9 "		
	13 "		
TOTALS:			
General—212	369	144	253
Males: 212	99	143	245
Females:	270	1	8

water, gave only in the whole period of her laying, and in the last eggs, a single female (No. 524–10 of the following table). Just as the generative faculty diminishes with age, it diminishes also with the number of couplings. The female gives fertilized eggs developing into females in the proportion of the power of the male. In the cases where the coupling has been

with a feeble or exhausted individual, at the beginning the descendants are normal; then, after a certain number of layings, quickly one finds no more females, as with the virgin animals. And, in spite of that fact, I have not been able to obtain a second coupling.

TABLE OF REARINGS.

Numbers:

524—26 B Female Couples after 5 Depositions. Issued from Cocoon Sept. 2, 1921. First Deposition on 6th. Coupled on 12th. *Detail of the layings*	599—34—A Female Coupled. Reared in Air-chamber at 30°–32°.
15 males	14 males 1 female
18 "	17 " 10 "
6 "	1 " 18 "
20 "	1 " 6 "
15 "	4 " 5 "
Coupling	1 " 6 "
1 male 28 females	0 " 27 "
2 " 12 "	0 " 24 "
1 " 14 "	0 " 32 "
2 " 20 "	0 " 32 "
0 " 15 "	0 " 30 "
0 " 6 "	0 " 27 "
0 " 12 "	0 " 19 "
0 " 13 "	0 " 18 "
0 " 3 "	0 " 31 "
1 " 15 "	21 " 4 "
0 " 14 "	11 "
0 " 11 "	20 "
1 " 12 "	20 "
1 " 9 "	14 "
1 " 13 "	7 "
1 " 8 "	
1 " 14 "	
1 " 24 "	
0 " 4 "	
6 " 1 "	
6 " 4 "	
TOTALS:	
General: 351	421
Males 99	131
Females: 252	290

MORPHOLOGY

The egg: The freshly laid egg is elongated cylindrical, usually slightly arched, the two extremities rounded but unequal. The one somewhat globular, larger than the other, will contain the head of the young larva.

The color to the naked eye is a brilliant milky white; under high magnification it is yellowish. The surface is delicately granular, without sculpture.

The dimensions on the average are (in millimeters) 0.550 in length, 0.155 for greatest breadth, and 0.122 at least breadth. There are slight variations, the maximum length which I have observed, and which was of an egg laid by a very active female in summer, being 0.572; the minimum length of an egg laid by a feeble female was 0.463.

The larva: Three stages are to be distinguished in the larval life. They are characterized as follows:

Stage I. The young larva, on issuing from the egg, is hyaline, almost transparent; under the lens there may be distinguished in the middle a clear yellow stomach; the head is globular and stronger than the rest of the body. Thirteen segments are separated by slight constrictions, and these segments have no particular characters except the spiracles. The last one bears the anus.

The body wall is unarmed, without pigmentation. The dimensions of the larva are on the average: total length, 0.5075, for the head alone, 0.1050, and the length of the first segment after the head, 0.2625.

The head (Fig. 17) bears on its dorsal surface two minute non-segmented antennæ, and on its lower side the mouth organs and the sensorial bristles which surround them. (We will study them in the adult larva.) The skeleton is formed by a chitinous arc which surrounds the buccal region. Each extremity of the arc is prolonged into a straight and delicate rod which leaves an open angle and terminates posteriorly on the cephalic capsule by two little perpendicular rods of unequal length. At each extremity of the chitinous arc is the triangular mandible, which is terminated by a strong sharp tooth, and whose lower border bears a remarkable comb formed of five sharp little teeth (Fig. 21, I). The total length of the mandible is 0.026, and the large tooth only 0.007.

The tracheal apparatus (Fig. 19) is quite visible, formed of a longitudinal trunk on each side of the body, while posteriorly in the 12th segment, the two trunks are united ventrally. In front, in the first segment, they are united dorsally by a large arch, slightly behind which the trunk divides itself into two branches to supply the head, the one internally, the other superficially. There are nine spiracles: one mesothoracic on the posterior border of the first segment, and eight abdominal on segments IV–XI. On each lateral trunk there are ten secondary dorsal and eleven secondary ventral trunks; the dorsal ones have their origin in the anterior region of the corresponding segment and are simple; the ventral ones, except the first, have their origin a little behind the others. The first two and the eleventh ventral trunks are simple; the eight others are bifid, with one superficial ramifying branch,

and another deeper, unbranched, joined to the corresponding opposite pair; they form as many ventral commissures as there are abdominal spiracles.

Stage II. After the molt the young larva passes to Stage II; its aspect changes and it takes definitive form, which holds until the full grown stage, with only a greater size. This stage is characterized only by the size of the mandible, which on the average is 0.040 long with the large tooth only 0.012; the comb is formed of seven little teeth; the head measures 0.1800 broad by 0.2275 long (average taken from ten larvæ of different rearings). The skin is covered with spines and sensorial hairs placed as in the following stage.

Stage III. (Fig. 16.) In stage III the larva becomes full grown, and of a size which varies according to the nourishment which it has had. In general the length is about 3 mm. and the breadth 1.5 (for normal individuals).

The general form of the body is approximately cylindrical and slightly arched, and tapers off at the extremities, rather more rapidly toward the head than toward the posterior end. On the back are permanent convexities, very apparent segmentary protuberances which are especially developed in the middle of the body. On the anterior border of segments II to XI, their surface is always smooth. These protuberances are capable of contracting and dilating and play a part in the locomotion of the larvæ enclosed between their host and the substratum.

The head (Fig. 20) is distinct from the first segment; it is large and well differentiated, placed on the ventral side and at its extremity a little below is the mouth surrounded by the mouth-parts. The labrum, an oblong sclerite, three times as long as broad, hollow in the center of its interior border, carries on each side three circular sensorial organs, and nearer the center two others in the shape of bristles. The maxillæ (M) are represented by a circular area without distinct appendages, except a tubercle between two bristles. The tubercle may be the vestige of a maxillary palpus. The labium (L) is the most prominent of the mouth parts; of trapezoidal shape, it carries the irregular orifice of the silk glands in its center, not far from the outer border; below, on each side, a little tubercle, divided in two, probably represents the labial palpus, under which are two sensorial hairs.

The mandibles (Fig. 21) measure 0.072 in total length, the large tooth only 0.016, and the comb comprises nine denticles.

The head still carries on its dorsal side the two antennary organs (A), which are quite small and composed of a prominent disk surmounted by a truncated cone. On the ventral face there is a series of ten sensorial organs, each formed of a small round disk bearing in the center a long and slender hair. These sensorial setae lie in an irregular series around the labium. Two other sensorial setae occur between the antennæ. Finally on each side, ventrally, a quite narrow area ending in an angle is clothed with little spines.

The first segment of the body is completely surrounded with spines; they occupy the whole surface in a large band formed of series without

order, the points directed outward. In the middle of the segment there is a belt of sensorial hairs in a regular single row (18 to 22). The orifice of the spiracle occurs near the posterior border of the segment at the limit of the band of spines, but it is surrounded by a lateral band which fuses with that of the following segment.

The second segment is not entirely surrounded by spines. The spine band does not reach to the borders of the segment; there is a glabrous space on each side. This area is enlarged towards the base and ventrally

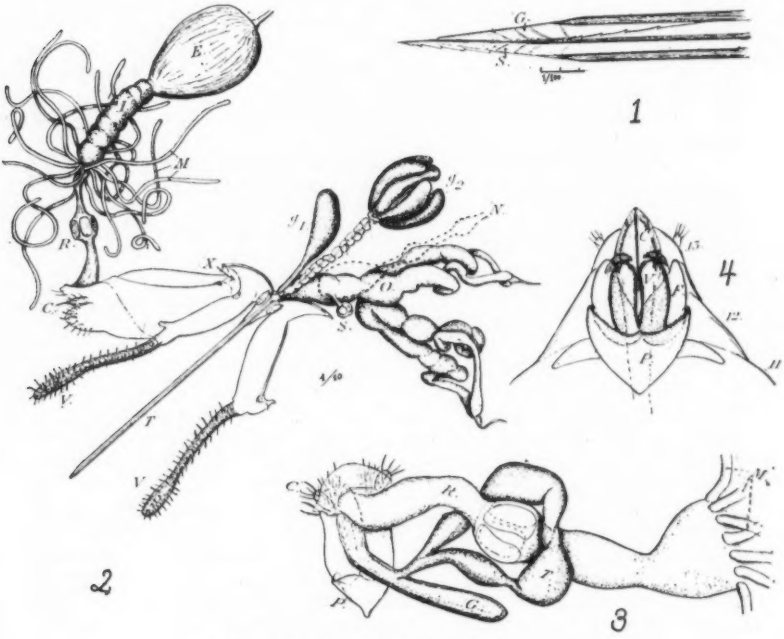


FIGURE 1. Distal end of the ovipositor.
S—Stylet; G—Gorget.

FIGURE 2. Female genital organs and digestive tract.
E—Gizzard; I—Chylific ventricle; M—Malpighian tubules; R—Rectum and rectal glands; C—Cerci; t_8—Eighth abdominal tergite; N—Nerve chain; X—Chitinous arc of stylet; V—Valve; T—Ovipositor; G_1—Alkaline glands; G_2—Acid glands; S—Spermatheca; O—Ovary.

FIGURE 3. Male genital organs and part of digestive tract.
M—Malpighian tubules; R—Rectum and rectal glands; C—Cerci; T—Testis; G—Accessory gland; P—Basal piece.

FIGURE 4. Male copulatory organ.
11 and 12—Tergites of eleventh and twelfth segments; 13—Anal segment with cerci; V—Valvula (valvella); C—Uncus; F—Forceps; P—Basal piece.

an unarmed surface separates the wedgelike extremities of the belt of spines. The band terminates with a few sparse spines. In the middle of the segment there is a belt of sensorial hairs as in the first segment (20 to 24). In spite of the absence of a spiracle in this segment, the lateral band is present and unites the second armoured area with the third.

The dorsal segmentary protuberance is unarmed, as in all the following segments. The third segment carries an armed band still narrower and also shorter, but the belt of sensorial hairs is complete and composed of the same number.

From the fourth to the twelfth segment, the armed surface is about the same, extending dorsally from the center of the segment to the spiracle and from there finishes in an angle before reaching the ventral face, which is entirely smooth. There is always a complete belt of sensorial hairs.

The thirteenth segment is unarmed; around the anus one finds only ten sensorial hairs in the form of a circle.

The body wall is formed of an external chitinous coat and an internal hypodermic layer. The hypodermal cells (Figs. 33 and 35) are polygonal, lozenge-shaped, with definite contours; in the portions covered with cuticular spines, the bases of the spines are situated above the nucleus and generally above the center of the cell.

The sensorial hairs or bristles are fine and long and are quite different from the cuticular, non-sensorial spines. Their length is 7 to 10 times greater, and they arise from minute circular concave areas in the cuticle. The trichogenous cells which are in communication with a nerve running around the segment are quite distinct from the ordinary hypodermal cells (Figs. 29, P, and 35).

The coloration of the larva is variable, as we shall show in the portion of this study which concerns the biology. It varies from light rose to a violaceous brown; the white urate cells (Fig. 15, S), which are distributed along the sides of the body, stand out clearly against the uniformly dark background.

THE MUSCULAR SYSTEM

The wall of the body is closely connected with the muscular system; this system is strongly developed and may be considered under the three following headings:

1. The tegumentary musculature.
2. The musculature of the head and of the bucco-pharyngeal apparatus.
3. The musculature of the dorsal vessel, which I will consider together with the circulatory system.

The tegumentary muscles (Figs. 5, 6 and 29) are those which are inserted by both extremities on the body-wall. The median dorsal line and the median ventral line being occupied, the one by the dorsal vessel and the other by the nerve chain, show no tegumentary muscles. On each side of the body three muscular regions may be distinguished:

1. The dorso-pleural region.
2. The pleural region.
3. The ventro-pleural region.

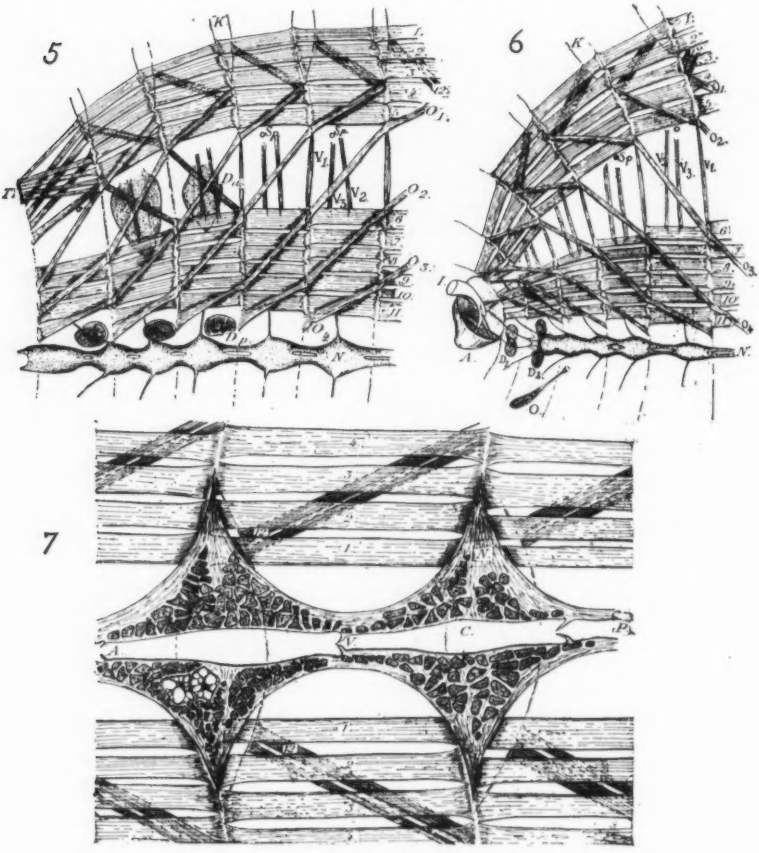


FIGURE 5. Muscles, imaginal discs and nerve cord from anterior part of body of third-stage larva.

N—Nerve chain; Dp—Imaginal discs of legs; Da—Imaginal discs of wings; Sp—Spiracles; T—Posterior margin of head; K—Dorsal segmentary protuberance (or transverse ridge); Sp—Spiracle; 1 to 5—Straight dorsal muscles; 6 to 11—Straight ventral muscles; 12—Oblique muscle from the ridge K; O_1 to O_4—System of oblique muscles; V_1 to V_3—Transverse muscles.

FIGURE 6. Muscles, imaginal discs and nerve cord from posterior part of the body of third-stage larva.

A—Anal segment; T—Rectum cut transversely, with its muscles; N—Nerve chain; O—Ovary; D_1 and D_2—Imaginal discs of female copulatory organs; Sp—Spiracle; 1 to 5—Straight dorsal muscles; 6 to 11—Straight ventral muscles; 12—Oblique muscle from the dorsal ridge K; O_1 to O_4—System of oblique muscles; V_1 to V_3—Transverse muscles.

FIGURE 7. Musculature of dorsal vessel.

A—Anterior direction; P—Posterior direction; C—Heart chamber; V—Heart valve; N—Diaphragms or wings of the heart with groups of pericardial cells. In the left anterior diaphragm are lodged two adipose cells. (Muscles are marked as in Figs. 5 and 6).

In a typical abdominal segment the dorso-pleural region has on each side five straight muscles (1, 2, 3, 4, and 5) attached by their ends to the anterior and posterior border of the segment, and two oblique muscles which cross at their posterior extremities, the dorsal one of these latter (12) situated between the straight muscles and the internal surface of the skin, the ventral one (0_1) under the straight muscles. The superior oblique muscle (12 Fig. 5) is longitudinally divided into two parts in almost all segments; it attaches above and anteriorly to the posterior margin of the segmentary protuberances (K) and below to the posterior margin of the segment here, together with the inferior oblique muscle (O_1). The pleural region has one oblique muscle (O_2) extending from behind and from above to below, and three transverse muscles (V_1, V_2, V_3), of which one follows the anterior intersegmentary line, while the others traverse the middle of the pleural area. The ventro-pleural region has on each side of the body six straight muscles (6, 7, 8, 9, 10, 11) and two oblique parallel ones (O_3, O_4) extending from the rear forward and from above to below, and situated under the straight muscles. These muscles, obliquing at the same angle, commence in the dorso-pleural region and are attached end to end so as to form a long oblique muscular band which crosses four segments.

The penultimate body segment has in its dorso-pleural region only three straight muscles, and in the ventro-pleural only four. The pleural region has a single transverse muscle.

The last segment has no tegumentary muscles.

As to the thoracic segments (Fig. 5), they are distinguished from those of the abdomen especially by the presence in the 2nd and 3rd segments of an oblique pleural muscle stretching from behind forward and from below to above, so that there are two oblique muscles which cross upon the imaginal discs of the wings. We also note here a reduction in the number of the muscles; in the pleural region of the third segment the transverse intersegmentary muscle is lacking; in segment 2 there is only a single transverse muscle situated in the middle, and none in the first segment. The number of the straight ventro-pleural muscles shows a reduction in accordance with the diminution of the area of this part of the body. Segment III still has six of these muscles, but segment II has only five, and in segment I only four. Moreover in this latter segment the dorso-pleural musculature is also modified, and there exist nine muscles, of which five, which are more or less oblique, are attached to the same border of the segment, while four others, oppositely oblique, that is to say, from below above, seem to be inserted anteriorly upon the posterior border of the head.

The musculature of the head (Figs. 9 and 10) is very complicated; it may be divided into the mandibular musculature, the musculature of the bucco-pharyngeal apparatus, and an added lower musculature.

As is to be expected, with this mass of muscles the head needs a very strong framework, and the chitinous skeleton plays this role. It is formed by a great double arch which surrounds the cephalic capsule on the lower surface; behind, it is prolonged into the interior by a chitinous rod, the tentorium (T, Figs. 8 and 10), which joins, below the

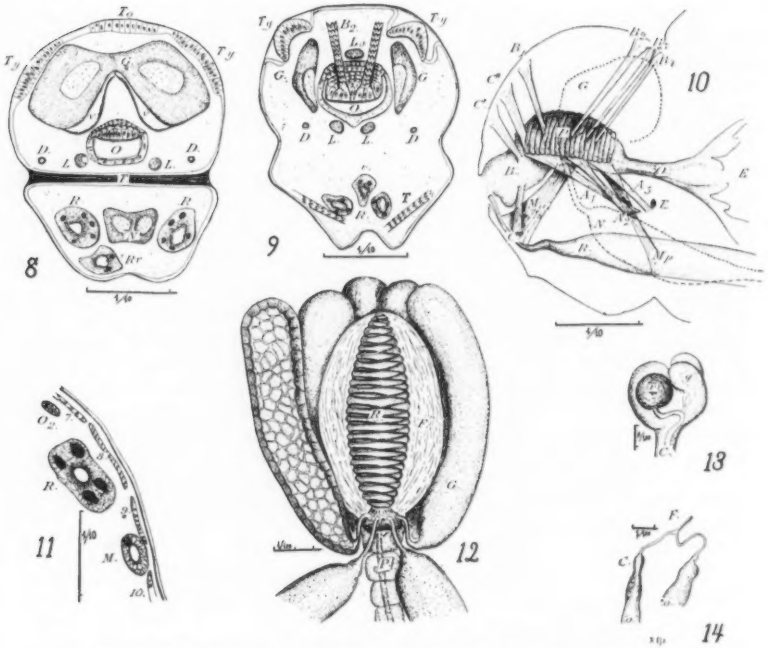


FIGURE 8. Oblique cross section of head from above the tentorium.

T—Tentorium; N—Nerve chain; G—Cerebral ganglia; V—End of heart, formed as a gutter; R—Salivary glands ("silk-glands"); Rr—Unpaired canal from the united salivary glands; O—Pharynx; D—Trachea; L—Sympathetic ganglia below the pharynx; To—Imaginal disc of the ocelli; Ty—Imaginal discs of the eyes.

FIGURE 9. Oblique cross section of head from above the second pair of the dorsal vertical muscles of pharynx.

R—Salivary glands; r—Canal from salivary glands; D—Trachea; Lo—Sympathetic ganglion above pharynx; L—Sympathetic ganglia below pharynx; Ty—Imaginal discs of eyes; G—Cerebral ganglia; O—Pharynx; T—Tegumentary muscle; B_2—Second dorsal pharyngeal muscle.

FIGURE 10. Sagittal section of head through the buccal-pharyngeal system.

B—Buccal cavity; N—Suboesophageal ganglion; G—Cerebral ganglion; A_1, A_2, A_3—Lateral muscles of pharynx; B_1, B_2, B_3, B_4—Dorsal muscles of pharynx; C′, C″—Oblique dorsal muscles of buccal cavity; C‴—Ventral muscle of buccal cavity; Mp—Posterior ventral muscle of pharynx to postero-ventral surface of head; Ma—Anterior ventral muscle of pharynx to labium; T—Cross section of tentorium; P—Pharynx with thick muscular coat of transverse bands; E—Gizzard; O—Oesophagus.

FIGURE 11. Transverse section through one of the ventral sides of an abdominal segment.

R—Salivary gland ("silk gland"); M—Malpighian tubule; O_2—Oblique muscle of ventro-pleural region; 7-10—Straight muscles of ventro-pleural region.

oesophagus, the two extremities of the arch. Anteriorly all the mouth-parts articulate with this arch or with its branches, as is shown in the figure. This skeletal arrangement divides the head into two unequal parts, the upper the larger, but both globular. The structure of this complicated region of the body can best be explained in connection with the figures.

Except for two little tegumentary muscles (T, Fig. 9) on the ventral face, all the other muscles are inserted on the one hand on the body wall, on the other on an internal organ.

On the anterior part of the head one sees on each side a great mass of muscles (M_1, M_2, M_3, Fig. 34). These three muscles are the motors of the mandibles and are attached as shown in the Figure, M_2 being an extensor muscle, M_1 and M_3 the flexors. The mandible articulates, by means of slight convex protuberances, one dorsal and one ventral, with two apophyses which are welded to the arch of the skeleton a little way from the labrum.

The mandibles of *brevicornis* do not cross, and their extremities hardly touch in repose, which leads me to believe that their role is limited to the piercing of the skin of the host and the fixing of the creature at that point, and that they do not masticate the tissues.

The absorption of food depends upon the energetic suction of the pharyngeal organ. This apparatus occupies the center of the head. It opens in front into the mouth, and posteriorly into the oesophagus.

The mouth is open and funnel-shaped. Its wall is clothed with cuticle: to the dorsal surface are attached two pairs of oblique muscles (C′ and C″), to the ventral face one pair (C‴). The mandibles move in the interior of the buccal pouch and its outer border is limited by the mouth-parts already described.

Behind the mouth at the point of the insertion of the muscles (C″) begins the pharynx, which extends for almost the entire length of the head and ends right above the tentorium (T) in the oesophagus (O), which is a simple tube.

The pharynx (O, Figs. 8 and 9; P, Fig. 10), nearly twice as long as broad, is an organ in the form of a gutter with raised borders, of which the upper wall dips toward the inferior wall. The pharyngeal cavity is clothed with a strong coat of chitin and one distinguishes, as in the skin, a primary and secondary layer. The epithelial cells of the dorsal wall are well developed and higher than broad. Immediately above this cellular layer is a thick muscular coat formed of three transverse superposed bands whose elements are attached on each side along the lateral folds of the organ. These fibers

---

FIGURE 12. System of acid glands.

R—Reservoir; F—Coat of muscular fibers; G—Acid glands, forming a crown around the central body; P—Duct surrounded by large cells.

FIGURE 13. Spermatheca.

r—Reservoir; g—Annexed glands; C—Deferent spermatic canal.

FIGURE 14. Top of an ovary.

F—Filament; C—Germinal chamber; o—Ovariole.

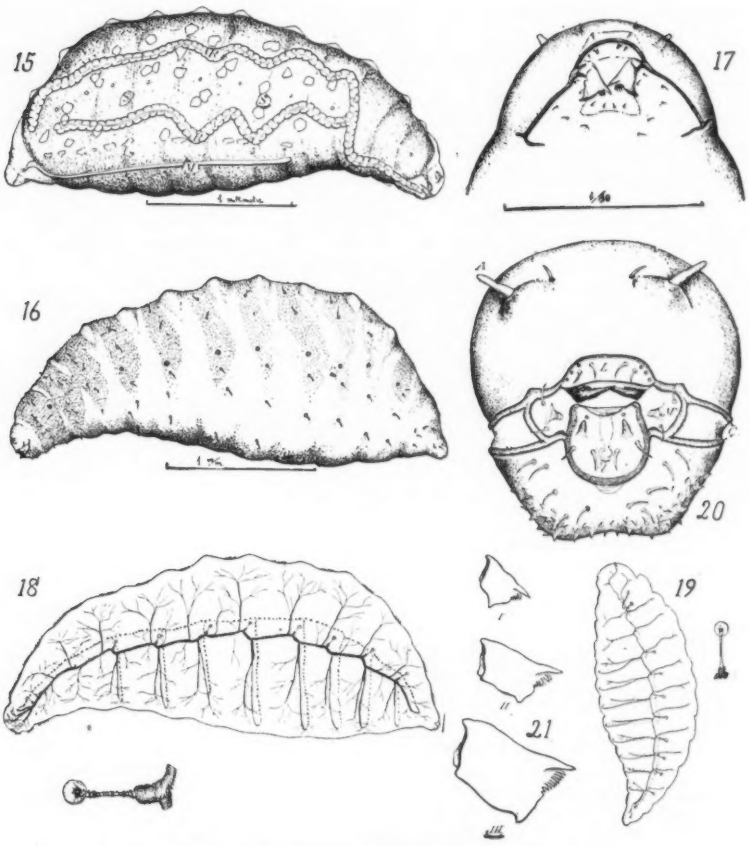


FIGURE 15. Mature larva, 3rd stage, 1 mm.
R—Salivary glands ("silk glands"); M—Malpighian tubule; S—urate cells.

FIGURE 16. Mature larva, third stage, 1 mm. External anatomy.

FIGURE 17. Head of young larva, first stage.

FIGURE 18. Mature larva, third stage, 1 mm. Tracheal system.

FIGURE 19. Young larva, first stage, Tracheal system.

FIGURE 20. Head of mature larva, third stage.
A—Antenna; L—Labrum; l—labium; M—Maxilla; C—Chitinous biramous arc. Mandibles in the interior of the buccal cavity.

FIGURE 21. Mandibles belonging to the three larval stages.

turn aside to allow the passage of four pairs of vertical muscles (B_1, B_2, B_3, B_4), which are attached on the one hand to the pharyngeal epithelial cells and on the other to the internal surface of the cephalic integument. The first pair is inserted behind the large discs of the head; the three posterior pairs are directed backward, and attach themselves to the summit of the cephalic cavity in the pleural region. On each side of the pharynx and attached along the line of insertion of the transverse muscles of the organ, are found three muscles which are directed backwards and are inserted near the chitinous arch of the skeleton (A_1, A_2, A_3). Finally to the ventral face are attached two pairs of muscles, of which one goes to the labium (Ma) and ends above the orifice of the silk glands, while the other (Mp) is inserted outwardly on the postero-ventral surface of the head.

The function of this apparatus is evident; it acts as a sucking pump. In contracting the vertical muscles elevate the upper wall, the lateral muscles hold the sides of the tube while the ventral ones hold the lower wall. The dilation of the organ induces an energetic suction and the nutritive material is absorbed. The transverse muscular fibers then come into play and draw the upper wall into the cavity of the organ. As all peristaltic movements are propagated from before backward, the nourishment is drawn into the oesophagus, which ends in the stomach. It is relatively easy to observe the passage of an air bubble and thus to have a clear idea of the absorption of nourishment. For this one takes a small larva, stage II for example, and places it on a slide under a microscope and examines it with lateral illumination. After moving the larva a little, it works its buccal-pharyngeal apparatus, which draws in air and one can see the globules pass through the organ.

The structure of the oesophagus (Fig. 30) does not merit especial mention. It is a simple tube formed of a layer of cells lined apparently by a very delicate cuticular intima. It ends in the stomach, into which its extremity is prolonged so as to form a rudimentary oesophageal valve.

The stomach or mid-intestine is a large pouch which occupies almost the whole body of the larva. It extends from the second thoracic segment to the eighth abdominal segment. The wall is formed of a layer of large flat cells without clear divisions between them. The cytoplasm takes stains well and is differentiated very clearly from the delicate membrane which lines the inner wall. The cells enclose numerous large vacuoles and a large nucleus. I have not noticed, as Seurat describes, that these nuclei were in a state of division. The growth of the stomach wall seems to be due rather to the increase in size of the elements than to their multiplication.

The lower intestine (Fig. 31), begins at the posterior extremity of the stomach, and forms in its anterior region a sort of a pocket on which are inserted the Malpighian tubules (M); it then retracts and immediately forms a little rectal ampulla which empties into the anus by a narrow conduit. But it presents nothing special; the epithelial layer is formed of a single layer of long narrow cells with little nuclei and furnished interiorly with a delicate layer of chitin and exteriorly with

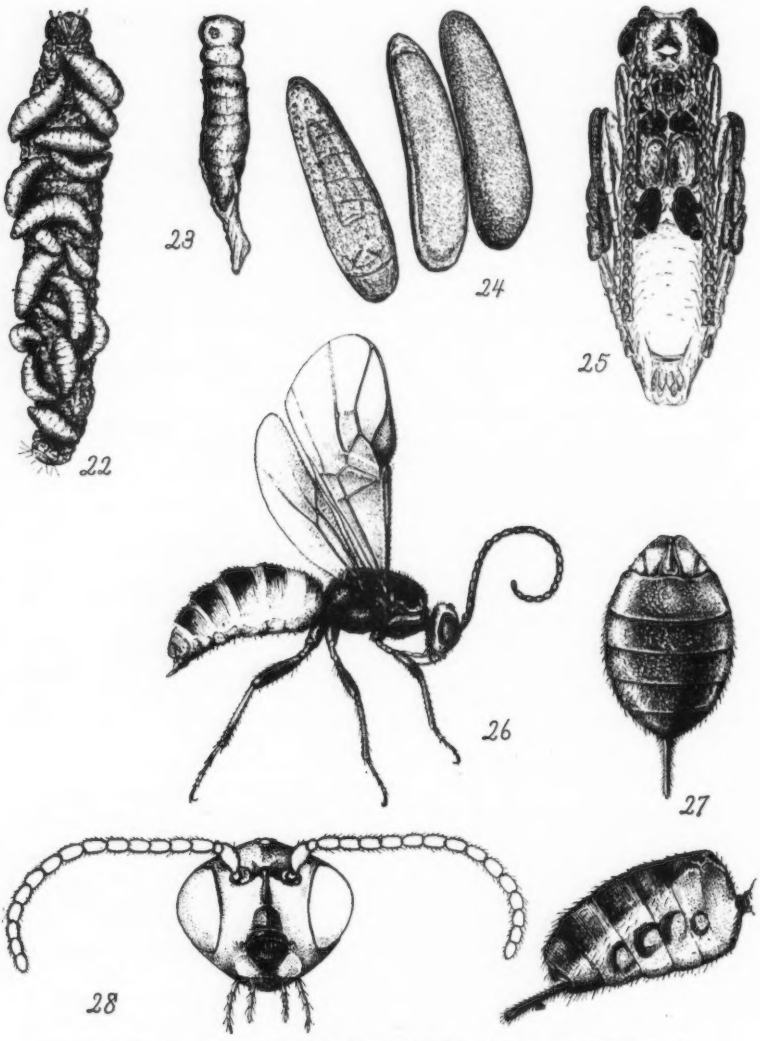


FIGURE 22. Larvae of *Habrobracon brevicornis* on a caterpillar of *Pyrausta nubilalis*.

FIGURE 23. Young larva emerging from the egg.

FIGURE 24. Three eggs. FIGURE 25. Male pupa. FIGURE 26. Male imago.

FIGURE 27. Abdomen of adult female. FIGURE 28. Head of adult female.

a layer of muscles. Around the rectum (R) is a little band of muscles (Fig. 6), two pleuro-dorsal fascia and two pleuro-ventral, one on each side, which are inserted on the border of the segment.

The Malpighian tubules (M, Fig. 15) which come from the intestine are two in number. They lie partly on the ventral surface and partly on the nerve chain, as far as the thoracic segments. They are rectilinear, of large diameter, and are formed by large cells with voluminous nuclei.

The silk glands (R, Fig. 15) are well developed and follow an undulating course between the wall of the body and that of the stomach, on each side of the insect as far as the posterior region (10th or 11th segment). They unite ventrally in the head near the opening of the labium, and open on the upper border of this sclerite through a very fine unpaired canal (R, Figs. 8, 9, 10). In the thoracic region they are simple, placed on the ventral side, then they pass dorsally bifurcating on the third thoracic or first abdominal segment, each branch presenting two or three undulations, one above the spiracles, the other below.

The respiratory apparatus (Fig. 18) is on the whole identical with that described in stage I; the tracheae which are visible in that stage have now become the primary canals which are greatly ramified, especially superficially. The lower deep branches have simply emitted some trunks at the ventral commissure, and these tracheoles aerate the zone of the nerve chain. The second pair of the stigmatic trunks of the thorax is well developed, but the spiracle is closed. The spiracles (Sp, Figs. 5 and 29) are placed in the dorso-pleural zone below the straight muscles, the second transverse muscle (V_2) arising below.

In the head the two tracheal branches have greatly ramified, the lower deep branch aerating the anterior part and the other spreads to the other parts.

The nervous system of the larva (N, Figs. 5 and 6) is formed of a double chain of symmetrical ganglia to the number of twelve. The sub-oesophageal ganglia are elongated and fused together. They are placed in the anterior part of the first segment. At the border of the head their apex rises and is united by the usual lateral commissure, passing in front of the tentorium to the cerebral ganglia (G, Figs. 8, 9, and 10), which are enormous and occupy the whole of the top of the head. On the dorsal side of the pharynx there is a ganglion (Lo, Fig. 9) emitting posteriorly a fine nerve, and below two symmetrical ganglia (L, Figs. 8 and 9) giving off nerves in the direction of the mouth, all belonging without doubt to the sympathetic system.

The ventral nervous chain includes eleven double ganglia; the first is pushed backward by the sub-esophageal into the second thoracic segment so that this segment appears to contain two ganglia; the others belong in the corresponding segments down to the tenth (seventh abdominal); in the eleventh the chain terminates by an elongate ganglion.

Each ganglion (N, Fig. 29) sends out a nerve running around the middle of the inner wall of the segment against the skin; in the middle it passes under the sixth straight ventral muscle at the intersection of

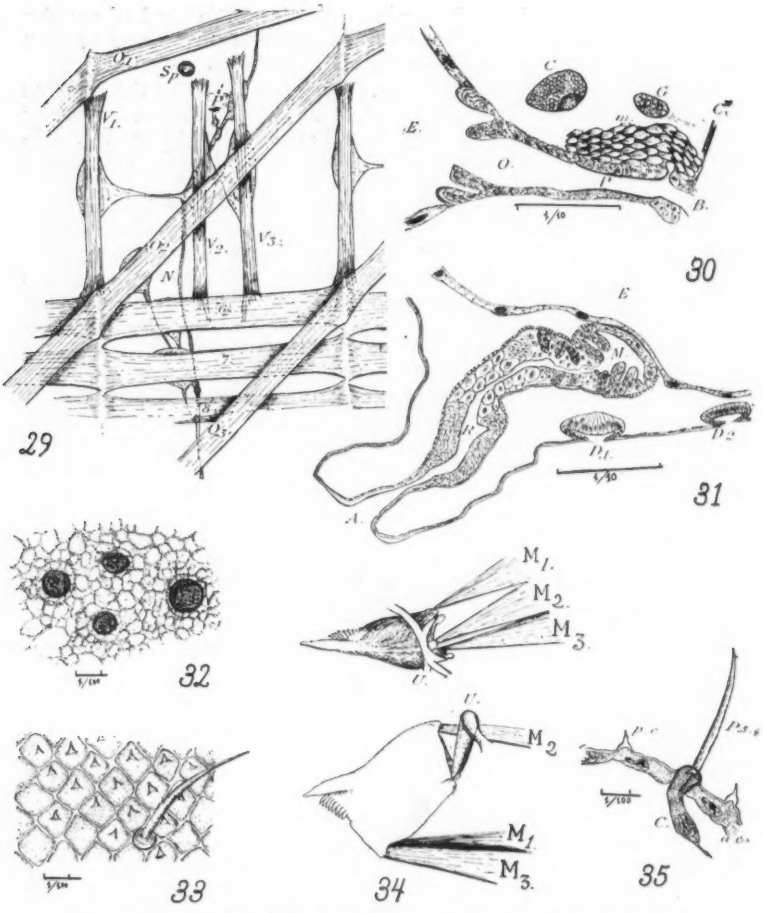


FIGURE 29. Nerves following the lateral muscles of an abdominal segment in the larvae.

N—Nerve; P—Sensorial hair; Sp—Spiracle; muscles are marked as in Figures 5 and 6.

FIGURE 30. Sagittal section along the middle of head of larva.

O—Oesophagus; P—Pharynx; B—mouth; E—Gizzard; C—Cerebral ganglion; G—Sympathetic ganglion above pharynx; m—Thick muscular coat of pharynx; C″—Dorsal muscle of buccal wall.

FIGURE 31. Sagittal section of posterior part of intestines.

E—Part of wall of chylific ventricle; A—Anus; R—Rectum; M—Place where Malpighian tubules are inserted; D_1, D_2—Imaginal discs of copulatory organs of female.

the great oblique muscle, then passes anteriorly and follows the central transverse muscle to its middle, where it gives out two branches; one goes to the transverse inter-segmentary muscle and the other, after innervating a sensorial seta, goes to the third transverse muscle and from this point toward the dorsum.

The last ganglion of the chain (Fig. 6) may be considered as formed of three united elements, for it sends out three pairs of nerves, the first pair running around the eleventh segment, the second around the twelfth, while the third goes around the anus to the thirteenth and last segment of the body.

The circulatory system (Fig. 7) does not differ much from the usual type. The dorsal vessel is a tube formed of elongate muscular fibers which runs from the hinder portion of the last segment along the whole length of the body. It presents in each abdominal segment an enlarged chamber with a pair of valves at the base; in the thoracic segments the tube is simple, without valves. This is the aorta which enters the head between the cerebral ganglia.

The heart rhythm is quite slow; the wave is continuous and propagated from behind forward. The groups of pericardial cells follow the movement of the wall of the vessel. These large cells (N, Fig. 7), having a very dense cytoplasm, form a triangular group above the wings of the heart. The wings are formed for each segment by a triangular mass of segmentary muscular fibers whose point is attached to the skin a little below the ridge. The wings fuse with their neighbors at the points where they are inserted on the wall of the dorsal vessel. Contrary to the definition of Berlese, they exist also in the thoracic segments along the aorta.

The adipose tissue is formed of enormous polyhedral cells filled with granulations. It floats in the body cavity between the body wall and the stomach. It is especially abundant laterally, being almost totally absent in the dorsal region.

Under the nerve chain are to be seen other adipose cells spread without order and in groups in the middle of the segments; they are very small and of no special form. Their size is variable and their area of dispersion does not reach the muscular region.

In the middle of the fatty tissue in the pleural zone of the abdominal segments are found the urate cells (S, Fig. 15). These cells are clearly visible in the living larva, and are plainly made out against the ground color of the stomach. Their number varies around thirteen for each side of the body, but they are spread without order and their disposition varies in different individuals. On the ventral face their zone of dispersal

---

FIGURE 32. Cells of the Gizzard, in face view.

FIGURE 33. Cuticula with spinules and a sensorial hair.

FIGURE 34. Musculature of mandible and mandibular articulation.

M_1 and M_3—Flexor muscles; M_2—Retractor muscle; U—Chitinous arc with apophyses.

FIGURE 35. Sensorial hair with sensitive cell.

Ps—Sensorial hair; Pc—Cuticular spinule; C—Trichogenous cell; a. e.—Ordinary hypodermal cells.

is strictly limited by a line parallel to the Malpighian tube. In cross-section these cells appear as large, sharply defined but of irregular contour, with a large nucleus and a very dense cytoplasm which takes stains very strongly.

The organs of the future insect are more or less apparent in the larva; in the head under the antennæ are found two large imaginal discs (Figs 5, 8, 9); the three thoracic segments carry the rudiments of the limbs. The legs are represented by three pairs of round imaginal discs. These discs are placed on both sides of the nerve chain in the posterior part of the segment. The large oblique muscles are inserted behind them. The first pair is in front of the nervous ganglia of the correspond ing segment, the second and third pairs behind ganglia 2 and 3. The imaginal discs of the wings are in the pleural region; they are inserted under the dorsopleural musculature and extend to the first right ventral muscle. These two pairs of discs are of unequal surface, the anterior one being more voluminous.

In the posterior region are found the rudiments of the genital organs (Fig. 31). These organs, as Seurat has pointed out, are already well differentiated. The ovaries are placed symmetrically near the nerve chain, and are formed of an oviform gland in the eleventh segment prolonged by a pedicel, the oviduct opening in the posterior part of the tenth segment; the female organ is therefore directed posteriorly. As for the male organs, the direction is the reverse; the testicle is carried on a short pedicel running backward. It ends in the intersegmentary fold between the twelfth and thirteenth segments.

The copulatory organs of the male are represented by a pair of short twin discs on the twelfth segment; those of the genital armature of the female by two pairs; the one placed in the posterior region of the eleventh segment is formed of two oblong separate masses, the other on the twelfth segment is composed of two paired and partly fused ovoid discs.

Pupa: The pupa (Fig. 25) is rather smaller than the larva, and all the adult organs are formed and placed in a symmetrical way on each side of the body. The antennæ form a long ribbon; in the male these reach the last joint of the tarsus of the hind leg; in the female they do not extend beyond the trochanter of the last leg.

The legs are folded upon themselves and on the sides of the body, the coxæ attached to the thorax, the trochanters bent and the femora alongside the tibiæ, and all are directed towards the anterior part of the body. The femoro-tibial articulations of the fore-legs lie beneath the eyes, while the last joint of their tarsi touches the middle coxa. The middle leg is folded up to the coxa and the upper part of the wing. Its last tarsal joint projects beyond the lower part of the wing. The hind leg, hidden below, is curved at the level of the attachment of the middle coxa, and its extremity touches the anterior margin of the last segment of the abdomen.

The wings are folded several times upon themselves, forming a wrinkled mass along the sides of the body. The palpi are extended along the thorax. In the male the sexual organs are folded on the

ventral face and arranged symmetrically. In the female the ovipositor forms a sort of ribbon folded upon the dorsal face of the abdomen and extending anteriorly to the penultimate segment. All the organs are covered with rather thick cuticle.

Cocoon: The cocoon is dull white, a little larger than the larva. It is made of tough silk threads and its consistency is firm. When one slits it, it offers a certain resistance like cardboard. Its shape is elongate cylindrical, with the two extremities ending in spherical caps. When the cocoon is isolated, it is surrounded by a fine net of silken threads placed without special order; several cocoons may be grouped under such a net, but each one is independent of the others. The regularity of the shape may be somewhat modified by the surface and the disposition of the substratum.

Description of the adults: The female is normally rather a dark brown color, its average dimensions varying around 3 mm. in length and 6 mm. in wing-spread.

The head (Fig. 28) is rounded in front, with the hind border vertically truncate. Seen from below, it is slightly transverse, as broad as the thorax; the slightly excavated occiput is black, the color extending more or less upon the head and toward the eyes, according to individuals. The black stemmaticum has three ocelli of a more shining black, placed in a triangle; on the face is a black spot of triangular form and prolonged by a little longitudinal carina. The eyes are round with a very slight depression near the fossæ of the antennæ. The labial palpi have three joints, the maxillary five, and their color is clear testaceous; the mandibles, which are massive and bidentate, are of the same color, slightly reddish at the extremity. The antennæ are inserted in the middle of the head at an equal distance from the epistoma and the stemmaticum, and have fourteen to seventeen articles. Their color is dark brown and they are densely haired, and are not longer than the head and thorax together. The scape is slightly swollen in the form of a reversed cone. The pedicel is about half the length of the first segment of the flagellum, which is the longest of the series. The others are of equal length. The last differs in form and is terminated in a point. The whole head is furnished with brownish hairs, especially around the mouth.

The thorax is black, with the mesonotum testaceous, and with three black bands on its lobes. The scutellum is testaceous, carrying a spot of greater or less extent at the base and at the extremity. The episternum is also testaceous. Brownish hairs scatter over all the surface. The wings are brownish, hyaline at the extremity, smoky in the basilar portion from the stigma; the stigma blackish with a more or less clear spot at its internal angle, which spot is accentuated by a clear trail in the smoky region. The veins are brown; the second abscissa of the radial vein is shorter than the transverse cubital vein. The second cubital cell is small, about half the size of the third measured along the cubital vein, which is colorless on leaving the second cell so that the first seems confused with the first discoidal. Legs testaceous with the coxæ, trochanters, the bases of the femora, and the tarsi more or less black, the whole covered with fine sparse light colored hairs.

The abdomen (Fig. 27) is black, oviform, depressed, the second suture rarely crenulate, the others smooth; the first segment testaceous, with its median triangular plate black and smooth; the second segment and the following ones are more or less narrowly bordered with testaceous on the sides, finely shagreened and sparsely covered with fine hairs. The venter is testaceous, with the borders of the segments marked by a darker spot. The ovipositor is about as long as a third of the abdomen; its sheaths are black.

The male (Fig. 26) differs but little from the female; its size is the same, but the body seems lighter and the coloration is less constant in a state of nature, as Marshall has pointed out. The general appearance is identical. The abdomen is more elongate, the first segment testaceous, more or less clouded, bearing a black median spot. The second is about the same, while the others are of an obscure color and the venter is clear, the corners of the segments marked by a yellowish spot. The last ones are brown, the penultimate only bordered with brown.

The antennæ have from twenty to twenty-six segments, and are as long as the body. Considered in detail, there are perceptible differences in the antennal structure in the two sexes. Each antennal segment bears narrow elongate parallel sensorial furrows and in each of these, toward the middle, there is a clear elliptical area which represents the olfactory fossa. Between the furrows there is a series of five or six sensorial hairs. In the male antennæ the fossæ are on the average .016 mm. in length and .004 in width. The scape and the funicle bear only hairs arranged in irregular series. The first 16 or 18 segments bear each 16 fossæ; the 3 to 5 following bear 12 to 14, and the last segment, 10. In the female the fossæ are smaller and measure .012 in length by .006 in width. The scape and the pedicel are identical with those of the other sex, but the first joint of the flagellum has six fossæ, the three following eight, the others ten, and the last, five.

The study of the internal anatomy of the adults is not included in the plan of this work, and I have not undertaken any detailed examinations. In his "Contributions a l'étude des Hyménoptères Entomophages," Seurat treats of this subject in detail. I will content myself with studying here the genital organs.

In the female these organs comprise the genital glands, the poison glands and the genital armature. The development of the genital glands varies according to the temperature. During the cold period, that is to say, when the temperature is lower than the normal springtime temperature (14° C.), the female does not lay eggs, and if the ovaries are examined at this moment, we find them reduced to small convoluted tubes, which enclose only a mass of cells. During the summer, on the contrary, the ovary occupies the greater part of the abdomen, the stomach is pushed into the antero-ventral region, the ovarioles are greatly developed, very long, and enclose eggs in all stages of development.

There are (Fig. 2) two ovaries, one on each side of the body, and each ovary is formed of a pair of ovarioles attached at the top by a single filament (Fig. 14) and they unite at the base before leading into the

vagina. The vagina is an elongate pouch which opens in front of the gorget of the ovipositor.

At the summit of the ovariole (O) the germinal chamber (C) has a light swelling, below which is a convoluted narrower region increasing in diameter below; as the oocytes, round at first, increase in size, they become more or less elongated oval while they descend, and issue in the fusiform shape of the eggs into the lower chamber.

In this anterior chamber the eggs accumulate to the number of four or five; this explains why the female can lay at a single period in a short space of time a considerable number of eggs (the maximum observed has been thirteen). This represents an enormous volume in comparison with the size of the body of the animal. If the lower chamber contained only a single egg, the reproductive organs would have to be capable of forming another egg while the first one was being laid.

The eggs lie longitudinally in the ovarian tubes. The large end is turned toward the summit of the ovary so that the head of the larva is directed toward the head of the female. Upon the dorsal side of the vagina toward the posterior extremity and near the arch of the gorget arises the deferent spermatic canal, imbedded in a double gland annexed to a globular pouch which is the spermatic reservoir (Fig. 13).

Behind the genital orifice, upon the dorsal surface of the ovipositor, is the orifice of the poison glands. This system is formed of two parts. The first part consists of a large sack-shaped gland, (G_1, Fig. 2) the neck of which opens directly behind the vagina. This is the alkaline gland and is formed of large, definite and regular cells and has no contractile fibers. The other part (G_2 Fig. 2and 12) is different and has the form of a globular body united to the genital armature by a very fine canal surrounded by large cells. This is the acid gland. The structure of this organ is very complex; being formed of a central part surrounded by a crown of glands. The central part is composed of an ovoid mass of muscular fibers (F) which encloses an elongate reservoir pouch, (R), the wall of which is striated by a chitinous spiral with a very regular course. At its base is a conical chitinous enlargement receiving the canals from the crown of secreting glands. These glands (G) are tubular and their wall is formed of large cells having regular and well defined outlines. They bend a little around the central mass, and their upper extremities are rounded. At the opposite extremity each gland terminates in a fine canal which bends in a sigmoid flexure and enters at the base of the reservoir. The crown comprises eight tubular glands.

It is easy to understand the mechanism of this poison apparatus. If we take a female in full activity and pull off the abdomen and put it in a little normal salt solution, life does not immediately cease and thanks to the testaceous color of the cuticular lining, one can see the wall of the reservoir and follow its movements. This internal reservoir behaves under the action of the muscular fibers which surround it like a spiral spring. When the fibers contract, the volume is diminished; when they relax, it expands. It thus functions like a rubber bulb which one presses in the hand, sucking the liquid from the secretive glands and ejecting it into the ovipositor. Its duct is very fine with an interior lining surrounded by large cells.

I shall not go into detail in regard to the genital armature, since Seurat has made a very complete study of this apparatus in a closely related Braconid, and the structure is quite similar. The ovipositor (Fig. 1; Fig. 2, T) is formed of three pieces, namely a gorget and two stylets. The gorget (G, Fig. 1) is derived from the eighth sternite and is a prolonged chitinous rod with a gutter on its ventral face, which extends quite to the extremity, where its borders approach and unite. The extremity is rounded. In the anterior region the borders of the gutter end in a scythe-shape plate to which are attached numerous powerful muscles. The gorget acts simply as a guide, in which the two stylets (S, Fig. 1) move; the extremity of each of these latter bears five little sawlike teeth. These stylets are the two pieces which are the active parts of the ovipositor, as they penetrate the body of the victim, regulate the issuing of the egg and direct its course.

In repose the ovipositor is retracted into the ventral part of the abdomen and is protected by a pair of valves (V, Fig. 2).

The male genital organs are simple. The copulatory (Fig. 4) is placed ventrally below the anal segment. It consists of chitinous pieces articulated by a basal piece (P). Seuret has given a detailed description of this apparatus for *Doryctes gallicus*. In this form the disposition of the parts is the same as that of *Habrobracon brevicornis*, only the shape of the pieces is slightly different.

The testicles (T, Fig. 3) are two pyriform masses, rather large, yellowish in color, which occupy the posterior part of the abdomen. They are joined at the top and the deferent ducts descend on each side of the rectum, which is thus completely encircled. These ducts join, emptying into an accessory gland which is attached by its posterior part to the base of the gonopophyses.

A COMPARATIVE STUDY OF THE POISON APPARATUS OF CERTAIN LEPIDOPTEROUS LARVAE.*

PAUL M. GILMER,
Division of Entomology, University of Minnesota.

That certain Lepidopterous larvæ possess poisonous hairs or spines is a fact well known to all entomologists. A real knowledge of such species, however, in general relates to such well known forms as *Automeris io* Fab., *Hemileuca maia* Drury, or certain of the Eucleidæ such as the saddle-back, *Sibine stimulea* Clem. To those within the belt infested by the brown-tail, *Euproctis chrysorrhea* Linn., the severe urticating properties of the larval spicules of this form are only too familiar. Yet, outside of these few forms, most entomologists consider the Lepidoptera as being harmless so far as any direct effect upon man is concerned.

A careful investigation of the literature brings to light the fact that poisonous properties are far from uncommon in this Order. A considerable number of nettling species occur within the boundaries of the continental United States, while if the eastern hemisphere and the tropics be included in the reckoning the numbers become very largely augmented.

Under ordinary circumstances none of the species are sufficiently poisonous to constitute a real danger, although Garcia, 1910, reports a case of poisoning of a child by a Megalopygid in the Valle de Cauca, Columbia, as being "severe enough to be considered potentially fatal," while fatal cases of pneumonic "Brown-tail rash" are not unknown. Such cases must, however, be considered exceptional. Nevertheless, the group contains species capable of inflicting quite painful injuries, and of setting up a dermatitis sufficiently severe to require medical aid.

It is very probable that cases of caterpillar rash are more widely spread than is commonly supposed. "Brown-tail rash" had been noted by physicians in the New England states for some years before the work of Tyzzer, 1907, and others definitely incriminated the larva of *Euproctis chrysorrhea*. Similarly

* Published as paper No. 498 of the Journal series, Minnesota Agricultural Experiment Station.

Knight, 1921, mentions the occurrence of a number of cases of an obscure urticaria observed by Minneapolis physicians before his experiments definitely showed the white marked tussock moth, *Hemerocampa leucostigma* Sm. & Abb. to be the cause. It is very probable that many of the so-called "hives" and other summer urticarias are due primarily to caterpillar hairs, and in obscure cases search should always be made for a history of exposure to such forms. The rash may be wide-spread over the body and the swelling, irritation, and secondary infections may be of a quite serious nature.

In no case have poisonous properties been definitely identified as being inherent in the adult form. A number of species, all belonging to the genus *Euproctis* Hubn. or its near allies, have had the adults reported as urticating. Anderson, 1885, showed that in the case of *E. chrysorrhea* the urtication is due to larval hairs spun into the cocoon, and removed therefrom by the anal tuft of the adult as it emerges through the cocoon walls. All evidence points to a like origin in the other reported cases, since the hairs have the morphological characteristics of the larval hairs in every case.

So far only one of the Rhopalocera has been reported as poisonous; *Vanessa io* Linn., upon the authority of von Gorka, 1903. To this I can now add *Euvanessa antiopa* Linn., from my own observations. It is probable that other closely related spiny Nymphalid larvæ also possess the property. Otherwise all known forms are Heterocera.

The number of families implicated is fairly numerous, and they are rather wide-spread throughout the Order. They include the families *Liparidæ*, *Notodontidæ*, *Megalopygidæ*, *Eucleidæ*, *Arctidæ*, *Noctuidæ*, *Saturniidæ*, and *Nymphalidæ*. It is very probable that the above list is an incomplete one. All forms which are pronouncedly hairy, or possess true pointed spines should be viewed with suspicion.

In no case where urtication was noted did histological examination fail to show a structural basis for the belief that a true poisoning exists. The magnitude of the reaction varies greatly with the individual attacked, while with many species the degree of poisoning is very slight at the best, probably serving merely to irritate the oral mucous of such birds and animals as may attempt to devour them. Only a careful histological examination of hairy or spiny forms, accompanied

by carefully checked "infection" experiments upon sensitive subjects can determine in doubtful cases whether the property be present or not. These have been the criteria by which poisonous properties have judged for the purpose of this investigation.

The history of the study of these forms consists of a number of isolated and independent investigations of individual types. Knowledge of the poisonous nature of certain forms is very old. Dioscorides the Greek, and Pliny both mention *Cnethocampa pityocampa* Den. & Schif., for its vesicating properties along with the Cantharid beetles. Mediaeval writers mention the same species as an ingredient of so-called medical potions.

The limits of space forbid any extended discussion of the literature other than that requisite to an understanding of the immediate forms studied. However, since no compilation of the literature has hitherto been made, the more important works should be cited.

The first of any significance from the modern point of view are those of Will, 1848-1849, and Morren, 1849. That of Goossens, 1881 and 1886 follows, to be followed in turn by those of Keller, 1887, Fabre (English translation, 1916), Lauden, 1891, Beille, 1895, Packard, 1895, and the very excellent histological studies of Holmgren, 1895 and 1896. Ingenitsky published on *Ocneria monacha* Linn., in 1896.

A pause of some years occurred here, the subject again being taken up by von Gorka, 1903. Tyzzer's articles on the brown-tail, *Euproctis chrysorrhea*, came out in 1907, Potter's work in 1909, followed by those of Eltringham, 1913, Riley, 1913, Kephart, 1914, von Ihring, 1914, and Collins, 1915.

The latest papers to appear have been that of Knight, 1921, the very excellent one of Foote, 1922, Mills, 1923, and Gilmer, 1923. In all this lists twenty-five papers, which include all of the important ones available to the writer. Mills lists one or two Japanese papers which were unobtainable, but his article reviews them with sufficient fullness to permit a reasonable evaluation of their contents.

Up to the time this study was undertaken there had been practically no comparative work done. Very early in the attack the value of the comparative attitude became apparent. Problems in themselves almost unsolvable began at once to yield to the key furnished by the simpler forms. The problem is, after

all, a simple one fundamentally, showing a very definite relation to the simple facts already known concerning body wall histology.

SCOPE OF THE PROBLEM.

The problem contemplated a comparative study both of the various poisonous types known and of those whose actual virulence was still an open question. While the work contemplated especially North American species, a considerable number of foreign types were examined. Not all poisonous forms were obtainable; rarity, difficulty in collection and preservation for histological purposes, and the necessity of observing quarantine regulations in certain cases making the study of some forms impossible. However, all the families known to contain poisonous species were examined, and from the material at hand there was little reason to anticipate that those not examined varied to any marked degree from the members of their families actually studied.

Eight distinct families have been found to contain poisonous species. Of the Notodontidæ the processionaries belonging to the genus *Cnethocampa* Stevens, have long been notorious. All *Liparidæ* examined were poisonous, a condition probably common to all members of the family. All the *Megalopygidæ* were found to be poisonous, and again the character is probably one universal in the family. Of the *Arctiidæ* the genus *Euchaetias* Lyman, has been shown to possess urticating power together with the typical structures accompanying it, and it is very probable that a large number of other genera are also poisonous. Of the Noctuidæ the genera *Apatela* Hubn., and *Catocala* Schrank, have been definitely found guilty. About half of the *Eucleidæ* possess poisonous structures, two genera of the *Saturniidæ*, *Automeris* Hubn., and *Hemileuca* Walk., also being poisonous. Of the *Nymphalidæ* the genera *Vanessa* Fabr., and *Euvanessa* Scud., have been incriminated, although it is probably also a character common to all Nymphalid larvæ possessing stiff pointed spines.

The following species were examined: *Hemerocampa leucostigma* Sm. & Abb., *Euproctis chrysorrhea* Linn., *Apatela populi* Ril., *A. oblinita* Sm. & Abb., *Megalopyge opercularis* Sm. & Abb., *Megalopyge krugii* Dewitz, *Euchaetias egle* Drury, *Lagoa crispata* Pack., a species of *Catocala*, duplicates of which unfor-

tunately failed to rear through, *Parasa chloris* Her-Schaef., *Parasa indeterminata* Boisd., *Parasa latistriga* Distant, *Phobetron pithecium* Sm. & Abb., *Adoneta spinuloides* Her-Schaef., *Sisyrosea textula* Her-Schaef., *Sibine stimulea* Clem., *Automeris io* Fabr., *Hemileuca maia* Drury, *H. nevadensis* Stretch, and *Euvanessa antiopa* Linn. The known poisonous forms not examined included one *Hemileuca*, a number of *Eucleidæ*, *Porthetria dispar* Linn., and a number of uncommon *Liparidæ*. Information concerning a number of other types was obtained from the articles of other authors. These included a large number of Brazilian *Megalopygidæ*, *Ocneria monacha* Linn., *Cnethocampa pityocampa* Borowski, *Cnethocampa processionea* Linn., and *Euproctis* (*Porthesia*) *similis* Fuss.

Sections were made of all forms studied and especial study made of all glands in connection with body wall appendages. Form was compared with form, an endeavor being made to determine not only the nature of the structures involved, but also their origin and mode of functioning. Some work was done upon the nature of the poisonous substance itself, using the plentiful material of *Hemerocampa leucostigma*, as well as some of *Automeris io*. Although considerable was learned about the general properties of the toxic material, nothing concerning its actual chemical nature could be found out. It was evident, however, that it is not formic acid, nor cantharidin, but some highly toxic substance very closely associated with the protein molecules of the toxogenic cell itself.

METHOD OF PROCEDURE.

The greater quantity of the material was obtained from various correspondents already killed and fixed. The major portion was in Bouin's picro-formol reagent, which gave uniformly excellent results. Some were obtained in Gilson's and some in Petrunkevitch's mediums, both of which gave results equal to those of Bouin's. Large larvæ were slit to permit the fluid to penetrate more easily.

The material was preserved in 80% alcohol until wanted for use, then run up thru the alcohols, cleared in cedar oil and embedded in paraffine. This should be of as high a melting point as is consistent with the material's preservation. That melting at from 56° C. to 60° C. was found satisfactory for most forms, although care must be exercised not to "cook" the

larvæ in the paraffine bath. With *Euproctis chrysorrhea*, paraffine melting at 53° C. was found more satisfactory.

Sections were generally cut at ten microns, as thinner ones tended to pull out of the paraffine, due largely to curling of the body wall chitin. Staining was done by two methods; Heidenhein's iron alum haemotoxylin, and Delafield's haemotoxylin with a counterstain of acid fuchsin (fuchsin S.). The latter combination was particularly well adapted to the work. Sections were finally cleared in xylol and mounted in xylol-balsam.

For the study of spines alone, recourse was had to staining in bulk with the Delafield's-fuchsin combination. The spine-bearing tubercles were clipped from the larva and stained successively in the haemotoxylin and fuchsin, periods of from twenty-four to forty-eight hours being necessary to get the desired results. The material was run up in bulk, twenty-four to forty-eight hours in each alcohol and not less than seventy-two hours each in the last alcohol and the xylol. The spines were cut from the tubercle with a safety razor blade just previous to mounting in thick xylol-balsam. This gave most beautiful contrasty preparations for study under low power.

HISTOLOGICAL STUDIES.

There are essentially two distinct types of poison apparatus found in Lepidopterous larvæ. A third type, found in the *Notodontidæ* and certain *Liparidæ*, has not yet become sufficiently distinct morphologically to warrant the erection of a type for it. It is quite evidently a modification of the primitive hair type.

The primitive hair type is a single seta which has become toxic due to the development of a venom gland in connection with it. This gland, no matter what the type of structure, is always unicellular, and is probably derived from the same hypodermal cell from which the trichogen is formed, since the cytoplasm of both gland cell and trichogen enter the lumen of the hair. The trichogen may, or may not, be demonstrable; quite often it degenerates, soon after the moult, so completely as to be very difficult to find.

Certain *Notodontidæ* and *Liparidæ* furnish a distinct subtype. The character of the seta has become so altered as to be almost lost, being replaced by a small bunch of from three to a

dozen spicule-like hairs, all arising from a cup-like structure connecting through a pore canal in the chitin with a unicellular gland beneath. The identity of this with the primitive type can be established with certainty sufficient to class it as a major sub-type of the latter.

The second distinct type has the seta augmented by a true spine. This latter is lined with a true hypodermis, and is surmounted at its tip by the more or less modified seta which preceded it. The poison spine is, then, an evagination of the body wall which has taken place at a point previously occupied by a seta. It has partially taken over the function of the introductory organ formerly filled by the seta alone. Again the arming is by means of a unicellular gland situated at the base of, or well within the lumen of the spine, and communicating with the exterior by means of the chitinous penetrating "point" furnished by the modified seta. The actual relationships with the hair type are obvious.

For the purpose of this article the term "spine" is as defined above. It is characterized by a peculiar flattened hypodermal lining, differing distinctly from that lining spurs and tubercles.

THE PRIMITIVE HAIR TYPE.

The simplest type is the primitive hair type. This type is displayed by certain *Liparidæ*, such as *Hemerocampa leucostigma* and *Ocneria monacha*. The Arctiid *Euchaetis egle* and the genus *Apatela* among the *Noctuidæ* also possess it.

It consists of a typical seta, usually somewhat smaller and stiffer than the others found on the larva, whose only easily noticeable point of difference lies in the presence of a large gland cell in direct communication through the "chitin ring" and pore-canal with its lumen. The cytoplasm of both gland and trichogen cells may often be traced side by side through the pore-canal into the hair lumen, where the trichogen protoplasm usually becomes lost, that of the gland cell filling the cavity more or less completely. The trichogen is not infrequently lost to view between moultings.

Such poison hairs retain their nature even after ecdysis. This is due largely to the fact that the venom is not a true secretion, but the cytoplasm of the gland cell functions directly as the toxic agent. The dried remnant within the hair lumen may retain its efficacy unimpaired for intervals of a year or more.

In *Hemerocampa leucostigma*, (Fig. 1) the greater quantity of the poison hairs are borne on the prominent white "tussocks" found upon the first four abdominal segments. They also occur in some numbers in company with the black "plume hairs" on the anterior and posterior dorsal tubercles, and in the lateral tubercles of all segments. In the dorsal tufts the cells of the hypodermis are so crowded as to give a stratified appearance to

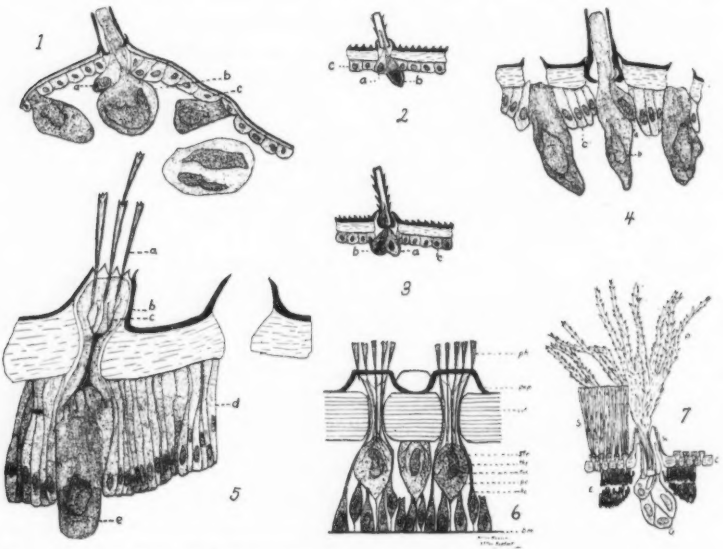


Fig. 1. Poison Seta of *Hemerocampa leucostigma* Sm. & Abb.
a.—trichogen cell. *b.*—poison gland cell. *c.*—body-wall hypodermis.

Fig. 2. Poison Seta *Apatela oblinita* Sm. & Abb.
a.—trichogen cell. *b.*—poison gland cell. *c.*—body-wall hypodermis.

Fig. 3. Poison Seta of *Apatela populi* Riley.
a.—trichogen cell. *b.*—poison gland cell. *c.*—body-wall hypodermis.

Fig. 4. Poison Seta of *Euchætias egle* Drury.
a.—trichogen cell. *b.*—poison gland cell. *c.*—body-wall hypodermis.

Fig. 5. Poison apparatus of *Euproctis chrysorrhea* Linn.
a.—spicule-hair. *b.*—cup. *c.*—poison (intracellular duct). *d.*—body-wall hypodermis. *e.*—pioson gland cell.

Fig. 6. Kephart's Figure of *E. chrysorrhea* Linn.
ph.—poison hair. *pap.*—papilla. *cut.*—cuticula. *str.*—strands of hair forming cells. *thr.*—threads of poisonous substance. *nuc.*—nucleus. *pc.*—poison cell. *hc.*—hair forming cell. *bm.*—basement membrane.

Fig. 7. Eltringham's Figure of *Porthesia similis* Fuss.
P.—Plume hair. *S.*—Spicules. *E.*—Epidermis (hypodermis). *G.*—Gland like cells.

the subcuticular tissue, while the trichogens may often be found so crowded into the gland cell as to appear as a part of the latter. The cell boundaries are often only distinguishable under the oil immersion lens. The typical ovoid nucleus of the trichogens as contrasted with the bluntly branched appearance of the gland cell nuclei serve to differentiate the two. It is probable from Ingenitsky's description that the apparatus in the nun moth *Ocneria monacha* is essentially similar.

In the *Apatelæ* the general structure is similar. In both *Apatela oblinita*, (Fig. 2) and *A. populi* (Fig. 3), the venomous hairs are found scattered over the dorsum among the hair tufts. They are considerably more numerous in the form *oblinita*, whose rather greater virulence may be accounted for by its more abundant armature. The setæ are less crowded than in the tussock moth, the trichogen showing fairly clearly as a rule beside the rather small gland cell. The latter is but little if any larger than the trichogen and is distinguishable only by the bluntly lobate nucleus.

In the harlequin milkweed caterpillar, *Euchætias egle* (Fig. 4), the poison setæ are confined largely to the orange and black tufts on the dorsum. The cells are closely crowded together, the glands being long, somewhat contorted cells with the hypodermis in long narrow oblongs or spindles between them. The general appearance of the hypodermis resembles, at first glance, that of *Euproctis chrysorrhea*, except that the glands are less plump. The trichogens are demonstrable only in a very few cases, apparently normally degenerating early.

A simpler type than these afford is scarcely possible. Apparently an ordinary seta has become toxic by the simple process of developing a poison gland immediately adjacent to the trichogen. It is very probable, from the fact that both enter the hair lumen, that the gland cell is a sister cell of the trichogen.

THE MODIFIED SINGLE HAIR TYPE.

A considerable number of the *Liparidæ* and some *Notodontidæ* possess a modification of the primitive type so different as to make the process of homologization a difficult one. The form *Euproctis chrysorrhea* (Fig. 5), is typical of this group.

Upon the subdorsal tubercles of the brown-tail, *Euproctis chrysorrhea*, are to be found minute "papillæ" or cup-like structures closely crowded together. In these cups are borne from

three to a dozen short spicule-like hairs of a peculiar structure. They are from seventy to one hundred microns long, from four to five microns in diameter at the larger end and are composed of a series of partially telescoped units, the small end of each inserted into the three barbed larger end of the unit just below. The finely pointed end of the first unit is inserted in the cup.

The cups are continuous with the primary cuticula. They show a somewhat serrated appearance at the free upper edge, and are freely open and cuplike. The bottoms of the cups open directly into rather wide pore-canals passing through the secondary cuticula to the hypodermis beneath. The spicule hairs enter the cup between the serrations of the edge, their ends being free within the cup itself.

The cups are not very large, smaller in fact than the usual hair follicle which they resemble in many respects. The gland cell lies in the hypodermal layer immediately beneath the pore-canal, and is from three to four microns in diameter by three to six times that in length. The large, somewhat lobate nucleus lies at its lower end. The cytoplasm of the gland cell communicates with the cup above through the pore-canal, the ends of the spicule-hairs being embedded in it.

The space between the cups is usually less than the diameter of the cups themselves, the glands lying closely packed in the hypodermis, with the latter appearing crowded between them. Due to this intense crowding the hypodermis presents an abnormal appearance, the cells in place of being approximately cubical appearing in section as long narrow rectangles or even spindles, about ten microns across by six long with the nuclei crowded well into the lower end. Many cells are so crowded down as to appear to form a second layer, communicating with the cuticula only by means of long thread-like extensions.

Because of this crowding true interpretation of the facts is not easy. My own interpretation differs in a number of vital points from that of Miss Kephart, 1914, who first worked on this form. (Fig. 6). A very considerable part of the brown-tail material worked on consisted of Miss Kephart's own slides, hence the difference of opinion is one of interpretation primarily. According to Kephart the structures bear the following relations:

"The cells are divided into two groups, one composed of large cells 3.3 microns in diameter, the other of smaller ones

1.95 to 2.02 microns in diameter. The cells of the first group lie directly under the cuticle, and have crowded out the smaller cells towards the basement membrane, which gives a two rowed appearance to the hypodermis. The large cells, one of which lies directly beneath each hair-bearing papilla, are composed of granular protoplasm, corresponding in appearance with that of the ordinary hypodermal cells, with large nuclei which are, however, smaller in proportion to the size of the cell than those of the other group. In the cytoplasm there are fine threads of a darkly staining substance which converge towards the apex of the cell and unite into a coarser thread which passes through the pore canal in the cuticle and enters the papilla. There it divides again, one thread going to each of the hairs of the papilla.

"* * * * The cells composing the second group are very different from those just described. They are smaller; measuring from 1.95 microns to 2.02 microns in diameter. They are fusiform in shape, irregularly arranged, and appear as though crowded out of their regular position by those around them. There is comparatively little cytoplasm and it does not contain threads of poisonous substance. *These cells correspond in number with the hairs and each cell is connected by a strand of cytoplasm with the hair. The strands of cytoplasm are in fact nothing more nor less than portions of the cells which extend up around and between the poison cells, through the pore canal and papilla directly to the hairs. In other words, the smaller cells are the hair formative cells for this particular kind of a hair.*" (Italics mine).

The first paragraph of the above statement gives the facts as I found them. To much of the second I take exception. Insofar as it deals with the details of the size and general position of the smaller cells there is no disagreement. However, although I have observed, as did Kephart, the small thread-like prolongations of certain of these smaller cells, I have been unable to trace them to the pore-canal, but have observed them to end in contact with the secondary cuticula, both between the poison glands and between the very much compressed regular hypodermis. There seems no other manner of interpreting this than that they are nothing but ordinary hypodermal cells squeezed out of position by the pressure of the gland cells, and retaining their connection with the cuticula by means of

the long thread-like strands. It is probable that these threads constitute the so-called connective tissue of Beille in *Cnethocampa pityocampa*.

I have been unable to demonstrate any cell to which to role of the trichogen cell could be assigned with any certainty. As very often is the case, even in the more primitive type, it has probably degenerated. Examination of freshly moulted material proved fruitless, the very densely crowded condition of the hypodermis making any certainty in the matter impossible.

Adding weight to the interpretation given above is the indirect evidence of general insect histology. In no case that has come to my knowledge has a single celled gland of any sort communicated with the exterior through the medium of a number of such morphological units, independent of one another, as from three to a dozen separate hairs. In all other types studied the unicellular gland cell communicated with a single morphological unit; a single seta, or the point of a spine replacing a single seta. Many of the other *Liparidæ* show the gland as unquestionably issuing through a single seta.

But the evidence is not solely indirect. Examination of the cup shows it to resemble very closely the pore-canal or "follicle" of the ordinary seta. If it were the combination of as many as half a dozen or more setæ it should certainly be considerably larger in size than the follicle of a single seta. As a matter of fact it is smaller. The structure of the cup resembles closely the typical structures of the primary cuticula embracing the base of the ordinary seta and serving to brace and strengthen it. The pore-canal is typical except it lacks the chitin-ring characteristic of the hollow seta. But were the main shaft of the seta suppressed this chitin ring would disappear, leaving a plain, smooth pore-canal, with a papilla-like projection of the primary cuticula to indicate where the hair occurred. This is exactly what the present "cup" shows. The difficulty with the interpretation is to account for the three to a dozen small spicule-hairs all united in the use of a single follicle.

If we turn to Eltringham's article, 1913, on *Porthesia similis*, considerable light is shed upon the subject. He showed among the spicules certain large plume-like hairs with a great number of branches, the main shaft being so short as barely to issue from the chitin of the follicle. His statement follows:

"* * * * Amongst the dorso-lateral tubercles are found white plume-like structures, one of which is shown in Plate XXII, Fig. 2 (p). (*Fig. 7 of this paper*). Occasionally these rise off the dorsal tufts also. To the unaided eye their matted branches have the appearance of white spots on the larva. * * * * The plume-like structures arise from a chitinous socket differing little if any from the sockets of the larger branching hairs, and having at its base several cells, G, apparently of a glandular nature. The plume is quite as easily detached as the spicules."

It seems probable that the whole cup with its contained spicule-hairs is derived from a hair somewhat similar to that Eltringham found, by the further suppression of the main shaft, accompanied by a shortening and narrowing of the branches, each of which has become independently set in the cup. In this manner the derivation from a single morphological unit is accounted for, and the difficulties pointed out in the case of any interpretation similar to Miss Kephart's are avoided.

The only other point of difference concerns the dark staining strands of substance leading from the gland cell to the spicule-hairs. She interprets these as naked strands of poisonous substance; a not unlikely interpretation. However, I believe that the lines are too definite and their general characteristics too well fixed in all the cells examined to account for them on the basis of simple naked strands of substance. If this were the case there should be considerable variation in size, arrangement and course. The union into a single undivided strand and subsequent arborization to pass to the spicule-hairs would not be so constant. Small threads should be found occasionally differentiated from the single strand, since this by no means completely fills the pore-canal.

With the interpretation that they mark the line of movement of the poison from the gland to the spicule-hairs I agree thoroughly. I believe, however, that they are not mere strands of poisonous material but are actually small chitinous intracellular ducts, structures not at all uncommon in insect hypodermal glands, through which the poison is conducted from gland to spicule. This would account for the regularity of structure and uniformly undivided condition within the pore-canal. Either interpretation is, however, a reasonable one.

It should be noted in passing that in this type, only, is there any indication of the secretion of the poison as a separate entity, and in it alone has any record of solubility of the poisonous substance been recorded. Goossens records solution for *Cnethocampa pityocampa* as does also von Gorka; while Tyzzer and Kephart report solution for *Euproctis chrysorrhea*.

THE SPINE TYPE.

Certain well marked morphological structures, differentiating it from the simple hair type, characterize the spine type. The primary difference is the fact that it is not the product of a single enlarged hypodermal cell, but is, in fact, an evagination of the body wall, lined throughout its whole length, except the tip, by hypodermis but little differentiated from ordinary body wall hypodermis. The arming of the spine is done in exactly the same manner as in the single hair type; namely by a unicellular poison gland whose cytoplasm furnishes the poisonous material.

The families *Noctuidæ*, *Megalopygidæ*, *Eucleidæ*, *Saturniidæ*, and *Nymphalidæ*, all display some modification of this type of apparatus. In order, as given, they all show a fairly definite course along which evolution has probably taken place. Not that evolution has actually followed this particular series, but here, as elsewhere very often takes place, parallelism of evolution in different families has occurred, the same type of original structure undergoing independent but parallel development in families rather widely separated phylogenetically.

The spines vary, both as to length and diameter, between wide limits. The very fine spines in the *Catocala* are smaller than some setæ in other species, while those of *Euvanessa antiopa* are fully a centimeter long by two millimeters in diameter at the base. The spines are generally associated in some manner with a tubercle, and may be arranged in a rosette form, or may branch off rather irregularly from a main axis. In no case have they been found scattered indiscriminately over the body, but are confined usually to the dorsal, sub-dorsal or lateral tubercles.

The simplest form found was shown by a species of *Catocala* (Fig. 8) examined. Unfortunately the species was not determined as the one duplicate kept died in the insectary. The spines in this form are exceedingly slender, and are found in well defined rosettes intermingled with the peculiar hairs found fringing the lateral margins of the larvæ. They are shorter than

the accompanying hairs, and fully as fine in diameter as many of the latter. They are clear in color, acutely pointed; and are easily distinguishable from the gray spatulate hairs by means of the binocular.

The spine communicates with the body cavity through a chitinous papilla very similar to that associated with the ordinary seta. It apparently fits down into the pore-canal and even shows a rather typical chitin-ring where it takes its origin. Examination of these spines where partially opened by sectioning shows a peculiar, very fine reticulation within the spine itself. Under oil immersion lens this resolved itself into an exceedingly fine hypodermis, the cells being in many cases only two to three microns in width and much less in cross section. The nuclei, even under the immersion lens, appeared merely as dark staining pin-pricks. The whole lumen except the extreme point was coated with this exceedingly fine, flat, epithelial-like hypodermis.

A careful examination of the hypodermis in the region of the pore-canal showed that it passed up into and through the latter, going through the chitin-ring and connecting with the fine hypodermal lining within the spine lumen. At the lower entrance of the pore-canal the hypodermis was split, a sheet of one or two cells width bridging the gap between the edge of the pore-canal and a fairly large gland cell placed immediately beneath the latter. The basement membrane followed this sheet, passing beneath the gland cell, so that between the hypodermal bracing and the membrane the gland is held securely in place. Fig. 8 shows the structures as seen in section. The cytoplasm of the gland cell passes through the pore-canal and into the lumen of the spine, filling it more or less completely to the tip. The latter is very sharp, separated from the spine proper by a ring-like fenestrum, and is unlined with hypodermis. There can be no question but that the gland cell beneath is the venom gland.

It will be noted that except for the fact that the introductory organ is a many celled evagination of the body wall with a hard tip, there is no essential difference in structure from the mechanism as found in the simple hair type. The gland cell is located within the hypodermal layer immediately beneath the spine and communicates directly with the tip. This latter, as will be shown later, is merely a much modified seta.

What has occurred is obvious. There was originally in the present location of the spine a poison hair of the simple type. Through a slight widening of the pore-canal the hypodermal cells have invaded the region of the canal, where slowly through the course of evolution they have pushed outward, making a longer and longer evagination of the body wall, and carrying at the apex the original seta. This latter is now recognizable as the penetrating "tip," having shortened greatly as the spine grew in length. Since the outpushing in the present case has not been excessive in length the toxogenic cell has remained in its original position in the general hypodermal layer.

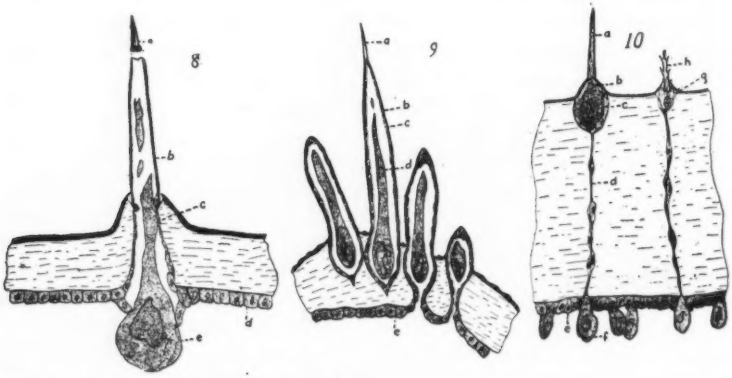


Fig. 8. Poison Apparatus of Catocala sp.
a.—spine tip. *b.*—spine. *c.*—spine and canal hypodermis. *d.*—body-wall. hypodermis. *e.*—poison gland cell.

Fig. 9. Poison Apparatus of *Parasa latistriga* Dist.
a.—tip. *b.*—spine. *c.*—spine hypodermis. *d.*—poison gland cell. *e.*—body-wall hypodermis.

Fig. 10. Poison Apparatus of *Lagoa crispata* Pack.
a.—spine. *b.*—"theca." *c.*—poison gland cell. *d.*—pore-canal hypodermis. *e.*—body-wall hypodermis. *f.*—gland-like cell. *g.*—trichogen cell for seta. h.—seta.

The spine of *Catocala* is very slender and sharp. It functions as does the hair type by breaking off in the wound. It is so delicate as to fail to penetrate the thicker epidermis of the hand or fore-arm but does penetrate, although with difficulty, the thinner skin of the under side of the upper arm. The degree of reaction is very slight, but it is sufficiently marked as to be distinctive and unmistakable.

The *Eucleidæ* show a slight evolution from the type shown by *Catocala*. About half the family are poisonous, the actual urticating ability varying greatly. Of the American forms, the saddle-back, *Sibine stimulea*, is probably the most venomous.

The spines in the *Eucleidæ* are borne upon the dorsal and lateral tubercles. Such forms as *Sibine* possess an extensive armature, practically every segment carrying two or more spine bearing tubercles. Practically all possess a pair of fairly large, erect, horn-like tubercles upon the anterior thoracic segments which are always the point of heaviest armature. In *Sibine stimulea* they are thickly covered with quite long, stout spines. Usually, however, the spines are rather short and stout.

Entrance into the flesh is made by means of the acutely pointed tip, which breaks off in the wound. The broken spine soon heals over, the free end becoming sealed with a brownish, gummy material, in all probability dried gland protoplasm. The spine is so heavy and stout that it is very probable that the broken stub may serve fairly effectively a second or third time.

There is very little difference displayed between the apparatus as found in the various forms studied. Rather broad variations as to length, number, etc., occur but none great enough to warrant special comment.

The forms investigated included the following species: *Parasa latistriga*, *P. chloris*, *P. indeterminata*, *Phobetron pithicium*, *Adoneta spinuloides*, *Sisyrosea textula*, and *Sibine stimulea*. This is only a partial list of the poisonous species of the family *Eucleidæ*, but is a fairly representative one. The group is one in which it is difficult to obtain material so that a number of known venomous species were not examined for that reason.

The species used as the type is *Parasa latistriga* Distant; (Fig. 9), a South African form obtained through the kindness of Dr. Faure of the University of South Africa. This type was used because of the excellence of the material and the good fortune of sectioning, which permitted the complete working out of the details of structure upon it. The work was subsequently checked in all important details upon the American forms available.

The apparatus showed the following characteristics. The spines, which are present in considerable numbers upon the large anterior and posterior tubercles, are short and stout, about two millimeters long by about one-sixth that in diameter.

The tip is acutely pointed, the point being long and tapering and sharply differentiated from the spine proper although there appears to be no well defined fenestrum between the two. The spine is lined throughout its length by the usual hypodermis of flattened cells. The point is without hypodermis.

At the point of union of the spine and the body wall is a bulb-like cavity composed of the widened proximal portion of the spine, and the much widened outer end of the pore-canal. This cavity is egg-shaped and is about two-thirds buried in the secondary cuticula of the body wall. There is no sign of a constriction at the point of juncture of the spine and bulb other than the gradual narrowing of the bulb lumen. No chitin ring appears.

There is a rather narrow pore-canal leading from the base of the bulb, through the secondary cuticula, to the hypodermal level. The hypodermis may be seen entering the pore-canal very distinctly, passing through and emerging at the base of the bulb to spread out and line both the bulb and spine as far as the penetrating tip. Lying within the sac formed by the hypodermal bulb lining is a large cell with the usual lobate nucleus of a gland cell. The nuclear lobes are short and blunt, appearing as simple excrescences. The contents of the cell stain very heavily with Delafield's hæmotoxylin, showing the presence of an immense number of minute granules. The cytoplasm extends up from the bulb, more or less completely filling the lumen of the spine, including that of the chitinous point. The nucleus lies wholly within the part of the cell inside the bulb, the cytoplasm above the latter structure being rather clearer and the granules somewhat coarser than those in the portion about the nucleus.

The general type is thus very similar to that found in the *Catocala*, the chief difference being the much larger and heavier spine and the fact that the gland cell has been pulled out of the primitive position in the body wall hypodermal layer and now lies well above the latter and within the chitin layer.

The other members of the family show precisely the same type of apparatus. The only differences are those of length, thickness, and relative numbers of spines. Even these features are not constant enough to be of any diagnostic value taxonomically, as the thickness and length vary greatly even in the same individual according to the location of the spine in ques-

tion; those of the horn-like tubercles invariably being longer and stouter than those found elsewhere on the body.

Closely allied to the type found in the *Eucleidæ* and in some respects almost intermediate between that form and the form found in the Catocala is the appartus displayed by the Megalopygidæ. All the family examined showed venomous properties, which are present so far as known in all members. There is little or no variation within the family itself, the resemblance in the apparatus in different species being so striking that certain of my own preparations might well have served as the originals from which some of Foote's microphotographs were taken. Yet my material was *Lagoa crispata*, while Foote's was *Megalopyge opercularis*. Three forms were examined: *Megalopyge opercularis, M. krugii* from Porto Rico, and *Lagoa crispata*. *Lagoa crispata* has been taken as the family representative for discussion.

The apparatus (Fig. 10) is borne upon a series of elevated ridges or rugæ, the spines being arranged in groups radiating out so as to form a small tubercle. The spines alternate with plumose hairs, a single hair appearing between each two spines on the tubercle. The rugæ run sub-parallel to each other and carry at least one or more tubercles on each segment.

Histological examination shows the rugæ to be very heavy chitinous masses, the cuticula being exceptionally thick. The spines originate on the top of this chitinous ridge and consist of the spine proper and a sort of cavity or bulb partially buried below the level of the primary cuticula, the upper third of the wall being a continuation of the latter. Passing from the base of the bulb through the thick secondary cuticula is a tiny twisted tubule, passing completely through the chitin wall and communicating with the hypodermis.

At the entrance of these tubules the hypodermis has assumed a peculiar whorled appearance (Fig. 11) the center of the whorl being occupied by a rather large pear-shaped gland-like cell which is in close apposition with the mouth of the tubule. In tangential section the whorls give an appearance somewhat resembling the nidi of the intestine.

Scattered through the secondary cuticula are little "islands" each consisting of one or more apparently isolated cells. A careful examination, however, shows that these cell islands lie in the line of the tubules, and are naught but widenings in

this tubule containing one or more cell nuclei with a very slight amount of cytoplasm about them. The pinkish red coloration of the lumen of the tubules when stained with fuchsin S show them

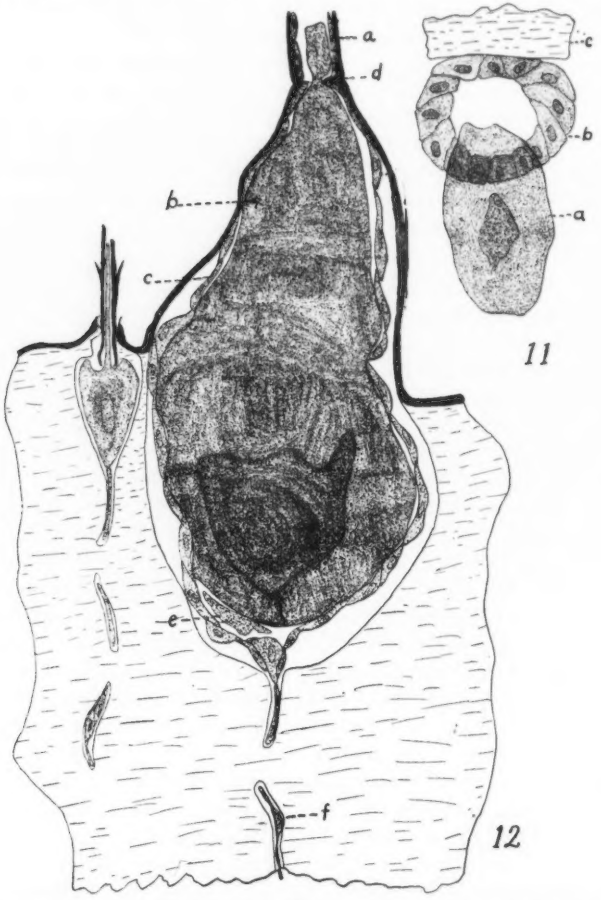


Fig. 11. Gland-like Cell and "Whorled Hypodermis." of *Lagoa crispata* and Other *Megalopygids*. (Tang.)
a.—gland like cell. *b*.—hypodermal "whorl." *c*.—cuticula.

Fig. 12. Theca, Poison Gland Cell, and Adjacent Structures of *Megalopyge krugii* Dewitz.
a.—spine. *d*.—fenestrum. *c*.—"theca," *b*.—poison gland cell. *e*.—withered protoplasm (possible trichogen). *f*.—pore-canal hypodermal cell.

to contain cell contents, as does the appearance of matter within the tubes at splits which occur due to artifacts. This material appears as a pink projection jutting out from the chitin edge.

There can be little doubt from these facts but that the tubules are occupied by living material, the nuclei of the cells occupying the widened portions. At the upper terminus of the tubule the protoplasm may be seen issuing from the tubule end and spreading out in the shape of flattened cells to line the bulb cavity. This lining is in turn continuous with the hypodermis which Foote showed lined the spine itself, the portion within the bulb constituting the so-called "theca" of Packard, von Ihering and Foote. There is then, a continuance of the body wall hypodermis up through the narrow tubule or pore-canal, lining the bulb and spine and ending where the hard penetrating tip begins. At the very base of the spine and separating it from the bulb appears a chitinous ring penetrated by a small opening, the "fenestrum" of Foote. The fenestrum does not differ markedly from the chitin ring in the follicle of an ordinary seta, and does, no doubt, serve the same general purpose, that is strengthens the body wall at the point of origin of the chitinous evagination.

Within the bulb itself, inclosed within the hypodermal lining, is a large cell usually so completely filled with a heavy staining mass of coarse granules as to completely obscure the nucleus. (Fig. 12). These granules stain with haemotoxylin and especially heavily with Heidenhein's iron haemotoxylin. The cell completely fills the bulb and its cytoplasm, passing through the fenestrum, fills the lumen of the spine, including the penetrating tip. There can be little doubt but that this cell is the poison gland cell, a very large one, but differing only in minor details from that of other forms. All previous workers have apparently missed this cell completely, or have mistaken the heavily staining contents as the poison secretion itself, an error easily excusable as the granules usually hide the nucleus completely.

An examination of the hairs beside the spines is illuminating. An exactly similar pore-canal penetrates the chitin, with a similar whorled arrangement of the hypodermis, including the gland-like cell at its inner mouth. As in the case of the poison spine, the pore-canal contains protoplasm of living cells and pocketed nuclei. The hair is borne from a small subtriangular

pocket within which lies the trichogen cell. There is no hypodermal lining to this pocket; the trichogen constitutes the end cell of the doubled series found within the pore-canal.

There is every reason to believe that from a structure similar to that described for the hairs the poison spine was developed. It is probable that the hair first became toxic, the pocket being occupied by both the trichogen and gland cell. Due probably to the widening of the pocket there was an invasion of that region by the hypodermis of the pore-canal, which in time came to completely line the pocket and by a process similar to that which has taken place in other forms, further pushed out to form the spine itself, carrying the old toxic seta at its distal end. The seta shortened to form the penetrating tip. The appearance of a true follicle chitin ring beneath the latter, together with the lack of hypodermal lining substantiates this view. Within the gland cell cavity there still often may be demonstrated a withered mass of material at the base where the hypodermis issues from the pore canal. This mass was noted by Foote and myself, and doubtless constitutes the degenerated trichogen responsible for the secretion of the spine tip.

Packard, von Ihering and Foote all believed that the poison was secreted by the gland-like cell at the hypodermal entrance of the pore-canal, and was stored in the theca. The reason for this mistake has already been commented upon. Just what is the exact function of this peculiar gland-like cell is uncertain. That it is not the toxogenic cell is fairly apparent. Their presence beneath the non-toxic plumose hairs as well as beneath the spines seems conclusive against the toxic theory.

Poisonous properties are not common among the Rhopalocera, being confined so far as known to the Vanessids and their allies. Of these forms, *Vanessa io* Linn., and *Euvanessa antiopa* Linn., have been found to be urticating.

In *Euvanessa antiopa* the spines are long and very heavily chitinized. They are arranged in very definite rows in a subdorsal position, four spines appearing on each of the body segments. Examination under low power binocular shows the spines to be thick, quite broad at the base, and branching. They possess two sorts of secondary appendages, the first being short, stubby spines; the other rather long setæ. The short sub-spines generally appear near the base of the main spine,

their place being taken farther up the primary by setæ. The main spine as well as the larger sub-spines end in rather long, sharp-pointed tips, cut off from the spine proper by the usual chitin ring. Certain of the sub-spines, however, end in setæ very similar to those coming off the main spine itself, except that the spine plus the seta is generally only about as long as the seta alone where the latter branches directly off the main spine.

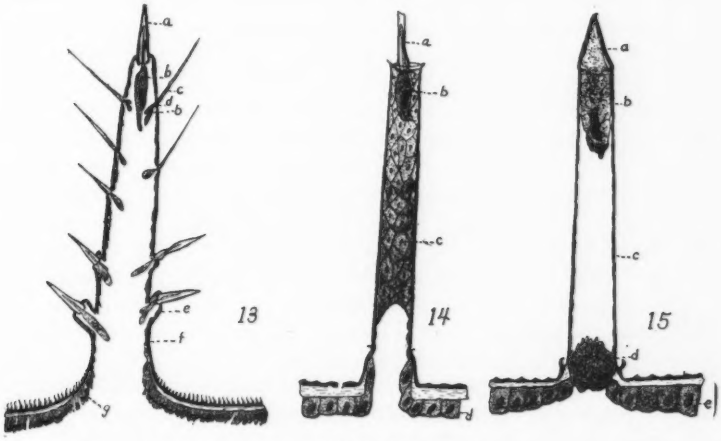


Fig. 13. Poison Spine of *Euvanessa antiopa* Linn. (Sect.)
a.—terminal spine point. *b.*—poison gland cell. *c.*—seta (substructure). *d.*—trichogen cell. *e.*—sub-spine. *f.*—spine hypodermis. *g.*—body-wall hypodermis.

Fig. 14. Seta-bearing Spine of *Automeris io* Fab.
a.—terminal seta. *b.*—poison gland cell. *c.*—spine. *d.*—body-wall hypodermis.

Fig. 15. Point-bearing Spine of *Automeris io* Fabr.
a.—terminal point. *b.*—poison gland cell. *c.*—spine. *d.*—transition hypodermis (?). *e.*—body-wall hypodermis.

By the use of material taken a few moments after ecdysis specimens may be obtained with the heavy secondary cuticula not yet laid down, and with the dark pigmentation completely absent. Good preparations may be made of such material either as sections or as whole mounts. The latter material may be stained in bulk, and shows very nicely general relationships, although sections are necessary for a detailed study of the relations of the trichogens to the hypodermis and gland cells.

Sections (Fig. 13) show that the main spine and the short subspines are lined throughout their length, except the penetrating points, by the usual flattened hypodermis, lying with the long axis parallel to the chitin wall. There is no sign of a true pore-canal, the opening of the spine into the body cavity being very wide, with the body wall appearing to bend up at a sharp angle. There is a rather distinct transition zone between the typical body wall hypodermis and the flattened spine hypodermis, extending for a short distance within the spine proper.

The sub-spines branch off the main axis in a similar manner, no sign of a pore canal being apparent. They are all short, usually not more than twice as long as broad, and are lined with a hypodermis similar in every respect to that of the main axis. Both in the main spine and the sub-spines the tips are demarked by the usual chitin ring. In close contact with this ring, passing through it and filling the lumen of the tip, is the poison gland cell, easily differentiated both by its shape and by the fact that it takes the haemotoxylin stains so heavily. It is very long and narrow, about eight times as long as broad in the main spine and somewhat less proportionally in the sub-spines. In especially favorable preparations there may be seen close beside the gland cell a second darkly staining cell much shorter but about of the same diameter. This cell also communicates with the tip through the chitin ring, and is almost certainly the trichogen which forms the penetrating tip. Further examination of the sub-spines bearing setæ show how this tip has been developed. In these cases there appears the same double armature, a large poison gland cell and a smaller trichogen. The seta is without doubt the product of the latter cell. But if the spine be extended somewhat and the seta shortened and broadened there will come a point where it is difficult to determine whether a "seta" or a "point" be present. Such examples are far from rare.

Further examination shows a similar gradation between main spine setæ and sub-spines. In some cases the sub-spines are mere offsets of the main axis, scarcely to be called a spine, while in still others the seta may be seen coming off a shoulder-like process on the main axis. These main spine setæ also show the double armature, possessing a poison gland cell of considerable dimensions and a small trichogen.

The cause of the appearance of so many armed units within so small a space on the spine is a question which cannot be answered with certainty. If the work of Fracker and others on the homologies of setæ and tubercles be taken into consideration some light is shed upon the subject. It is quite evident that the method of development of tubercles and of such spines as are found in the poison types are merely variations of the same general process, whereby a bulge is formed in the body wall, usually in the vicinity of one of the so-called primitive setæ.

Now it is a noteworthy thing that where large numbers of setæ are present in the larvæ they almost always appear close to the site of one of these primitive setæ, usually distributed fairly uniformly about the latter. Reflection as to the cause of this localization leads to the somewhat obvious first hand conclusion that the secondary setæ probably had their origin in the "anlage" cell of the original seta after its differentiation to a trichogen cell had gone far enough to determine the path of development for both daughter cells. This would account for the presence of two setæ where one had been previously, and in the course of time for the production of the usual "tuft" associated with the tubercle which has arisen at the site of the primitive seta.

A somewhat similar process has doubtless taken place with the poison setæ which grew originally at the apices of the poison spines. From the following considerations it seems rather the more probable that this division has taken place after the main spine had begun to develop.

There is a regular series from tip to base of the spine. Those substructures nearest the tip are practically undifferentiated setæ, those in the mid region are short sub-spines with setæ rather than points, those at the base consist of the longer sub-spines with well differentiated points in place of terminal setæ. Had the whole been differentiated before evagination of the body wall took place this arrangement would be unexplainable. Furthermore the evagination itself would not be a pushing out of body wall already formed, but due to increase in the number of hypodermal cells; that is the evagination would be new growth, not modification of the form of old tissue.

The only other alternative would be the differentiation of a large number of independent hypodermal cells into trichogens in certain localized areas. There would seem to be no particular

reason why such differentiation should be so local in its manifestation as to appear only about certain primitive or secondary setæ.

The difference in degree of development would argue for active production of the new setæ during the time of the development of the spine. The order of appearance of sub-spine, and seta from base to tip is just such as would be expected; the subspines being the older, cut off early and left stranded, as it were, at their point of origin. Being the older they have undergone the same sort of changes that produced the original spine from the original seta, and have begun the development of spines also, progressing to the point where their original nature as setæ is completely lost. Farther up the evolution has not gone so far. The sub-spines are, therefore, shorter, and the setæ which crown them, although shorter than undifferentiated ones, still easily classified as setæ rather than points. Last of all, near the tip, where the setæ are phylogenetically young, they are practically undifferentiated. The oldest seta of all, however, at the extreme apex of the main spine, has undergone complete transformation into a typical point.

Confirmation of the above hypothesis is given by a study of the ontogeny of the species. The first instar larva shows nothing but setæ, located at the sites of the primary setæ of Fracker. In the second instar this primary arrangement has become lost, and while again only setæ appear these are now located definitely at the sites of the appearance of the spines in later instars. These setæ are, however, borne on low "tubercles." In the third instar the spines first appear, about one millimeter long and crowned, not by a point, but by a pale seta, while a few short black setæ appear as substructures, the latter not mounted on sub-spines. In the fourth instar the spines have assumed much of the characteristics of the full grown larva, although the sub-spines are not yet fully developed. In the last instar the setæ of the larger subspines as well as the terminal seta have been replaced by typical points. A very full description of the various larval stages may be found in Scudder's "Butterflies of the Eastern United States and Canada."

One of the most interesting variations of this form from those that have been previously discussed is found in the migration of the poison gland cell to a site wholly within the lumen of the spine and closely attached to the penetrating point.

Here, apparently due to the relatively enormous length of the spine, the gland cell has been pulled from its old site even farther than in the *Megalopygidæ* and *Eucleidæ*. There is thus seen to exist a complete series, the *Catocala* showing the gland in the typical hypodermal position, *Eucleidæ* pulled up into the pore-canal and spine base, while *Euvanessa* and the *Saturniidæ* show it completely pulled into the spine lumen. It is to be noted, however, that it always in every case communicates directly with the penetrating tip, regardless of the position of the nuclear portion of the cell.

The *Saturniidæ* possess only two genera which are known to be poisonous; the genus *Automeris* Hubn., and *Hemileuca* Walk. All known species of these two genera are poisonous. *Automeris io* Fabr. is the only form plentiful in the eastern and northern states, although locally *Hemileuca maia* Drury, may be reasonably abundant. In the southwest and extending north into Colorado, western Kansas and Nebraska may be found the form *Hemileuca nevadensis* Stretch and its variants, often times occurring in such abundance as to be a menace to cattle raisers due to the poisoning of the range by the presence of the larvæ and their cast skins.

These forms, although disagreeable, do not compare with certain of the Eucleids nor with the Megalopygids in the violence of the reaction they occasion. *Io*, which has been taken as the representative of the family because of its abundance, and the fact that the apparatus is large and easily worked upon, is a reddish brown larva in the first two instars, becoming bright green in the later ones with a reddish to purple stripe on the lateral line containing the spiracles. The larva presents a veritable cheval-de-frise of spiny tubercles on the dorsal and lateral aspects, the greater number of the spines being actively venomous. In the grown larva these spines are from two to four mm. long by about one mm. in diameter at the base, gently tapering as far as the "point." The spines of *Hemileuca maia* and *H. nevadensis* are essentially similar in structure and general arrangement, although much shorter and fewer in number.

Examination with a hand lens shows clearly that two distinct types of spines are present, the one more common on the lateral tubercles, (Fig. 14), the other on the dorsal and subdorsal ones, (Fig. 15), although both sorts may be present on any tubercle.

The first type, more common on the lateral tubercles, bears, at its apex, a rather long and slender seta. Where present on the dorsal tubercles this type is, in the later instars, confined chiefly to the base rather than near the top of the tubercle. The end of the spine appears almost as though cut off at a slight angle. Set down into the end of the blunt spine in a sort of little shallow, cup-like, hollow is the follicle from which springs the seta. Substructures other than the terminal seta are not present in any case.

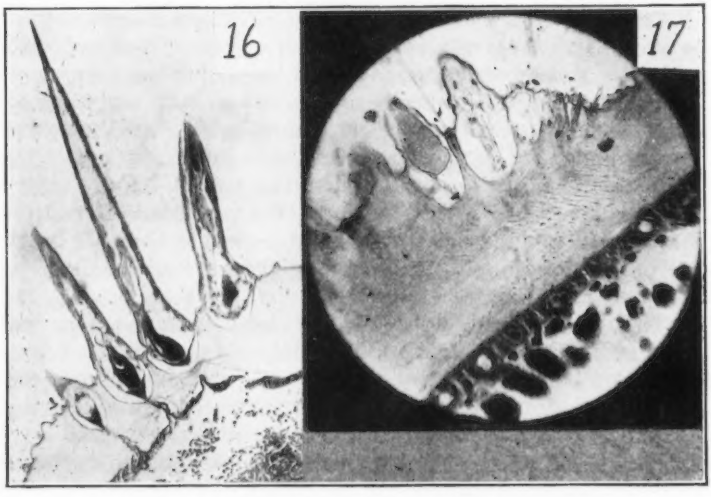


Fig. 16. Poison Apparatus of *Parasa latistriga* Dist.
Fig. 17. Poison Apparatus of *Lagoa crispata* Pack.

The other type of spine, found largely on the dorsal and subdorsal tubercles, is the functional venomous spine. In general appearance there is no easily distinguishable difference between the two types up as far as the apex of the spine proper, unless it be that those of the first type are slightly more slender than the second. In place of the slender seta, set down in a cup-like follicle at the spine apex, the second type possesses a heavy conical chitinous point, very sharp and of a brownish color. The length of the tip varies considerably, some being short and stout, with the height of the cone about equal to the diameter of the base, others rather more slender, with the altitude three

to four times the basal diameter. All agree, however, in that the base occupies the whole of the apical area of the spine proper.

At the union of the spine and tip there appears to be a suture. A careful examination, however, shows no such structure exists, the chitin passing smoothly over the point of union, the supposed suture being due to a slight but sudden constriction at the point corresponding to the follicle ring within the point. This latter structure divides the spine proper from the point, and consists of the usual heavy chitinous ring pierced by a circular opening communicating alike with the spine lumen and that of the point. This point lumen is very narrow, and the walls very thick and heavy. In freshly moulted material the tip is closed, but the first time the spine functions the extreme point of the tip is broken off, leaving a small "pore" opening into the lumen. This is closed by a gummy dried material, probably dried gland protoplasm.

Both types of spine are borne on a rather fleshy tubercle, conical in shape. It was thought at first that this tubercle might represent a step further in advance in the widening of the axial spine of such a form as found in the *Euvanessa*. More mature consideration has led to a different conclusion. Since as will be shown later there seems to exist a phylogenetic relationship between the seta bearing spines and the point bearing ones the appearance of the latter at the base of the tubercle rather than at the tips argue for an origin other than in the original trichogen now migrated to the extreme tip. Further the tubercle, while often ending in a spine, does not invariably do so, its apex sometimes being occupied by a pair of twin spines. It is now thought that there is here represented a tubercle caused by a rather active growth of the hypodermis about the site of a tuft of hairs or spines. The result has been to shove up the hypodermal layer, due to inability to expand laterally, into a conical shaped organ, carrying the hairs or spines with it. It differs from the type found in *Euvanessa* chiefly in that the growth in *Euvanessa* has been confined largely to the tip of the evaginated portion, while probably in *Automeris io* much of the growth has been peripheral, making in the first case a very narrow evagination or a spine, in the latter a broad-based shallow one or a tubercle. The spines themselves have grown in the usual method by the formation of a narrow evagination at the immediate site of the old seta.

It will be seen that *io*, while not constituting a true branching spine type, yet approximates it somewhat closely, lying in the intermediate ground between the usual low tubercle and the true branching spine. It is probable that the addition of elements in *io* has been not only by branching off from the original trichogen by division, but that the latest additions have probably been added rather by divisions of the older secondary trichogens or possibly by the development of new trichogens from the undifferentiated hypodermis. The basal position of the phylogenetically younger type of spine is hard to account for upon any other basis.

Both types of spines found in the *Saturniidæ* are poisonous. It has generally been considered that the seta-bearing type is non-venomous, and, so far as functioning as such is concerned, it is probable that they are not. The very long and slender seta bends before penetrating even very tender tissue. Not even on the thin epithelium of the lips and mouth could penetration be effected. However, there is at the base of the seta a small but characteristic cell so closely resembling the poison gland cell of the typical poison spine as to lead to the suspicion that its true nature was poisonous. Since direct inoculation by means of the seta had failed, recourse was had to clipping the tip of the spine with the gland cell in situ, boring into a hair follicle very gently with a fine needle and forcing the cut off spine, gland cell and all into the opening thus effected. The process of forcing the spine in brought sufficient pressure to bear to rupture the gland cell and force the contents into the wound. The result was a very violent reaction, comparable in every respect, except the much greater degree of violence, with that obtained from normal inoculation with point bearing spines. Check borings with the same cambric needle failed to produce other than a very slight local irritation, in no wise comparable with the violence of the inoculated boring.

When the course of ontogeny of the point-bearing spines is considered, that is that they are in the early instars seta bearers, and become point bearers with the succeeding moultings, there is very little reason to question the fundamentally poisonous character of the seta bearing spine. It is in fact the phylogenetic fore-runner of the typical functional poison spine.

If the point bearing spine be sectioned, there is revealed a lining composed of a flattened hypodermis, the cells pavement-

epithelial-like, with large rounded nuclei. The cells are irregular polygons in shape and about four times as broad as thick. They line the whole of the spine below the point, which, as is usual, possesses no hypodermis. The lumen of the spine is quite large, the upper part of it, often the whole of the upper half, being completely filled by a large ovoid gland cell with a somewhat lobate nucleus. This cell is crowded up against the tip, careful examination showing its cytoplasm passing through the orifice in the chitin ring and filling the tip lumen. The cell is an enormous one, and is generally partially filled with fine granules which take up the haemotoxylin stains very heavily. The apex and basal portions are especially heavily filled, being usually almost black from the depth of the stain.

At the very base of the spine, just within the lumen is a small body of rather small hypodermal cells forming a somewhat ovoid mass and almost filling the whole lumen at this point. They are probably transition cells between the usual type of hypodermis and the peculiar flattened type characteristic of the spine.

Examination of the spine base shows the body wall hypodermis of the tubercle bending up and into the spine through a rather narrow pore-canal. The chitinous structures show a joint-like appearance at the point of union of tubercle chitin with spine chitin. This appearance is doubtless due to the extra heavy chitinization of the body wall to brace the long spine. The appearance is almost as though the spine had been thrust up through the body wall, the cuticula of the latter appearing as though curled back at the point where the spine had been thrust through from the inner side.

Except that the spine is somewhat more slender and the hypodermal lining somewhat finer, the general morphological features of the seta bearing spines differ very little. The large gland cell is replaced by a smaller structure which is, however, morphologically the counterpart of the large gland cell of the point bearer. In exceptional cases a cell alongside the gland cell has been noted in both types. This is doubtless the trichogen, secreting in one case the seta and in the other the "point."

The point bearing spines function the most efficiently of any of the forms studied. The point, except the extreme tip, does not break off, as is usual with the other forms, but the whole apparatus functions much as a hypodermic syringe.

The point penetrates the flesh at a hair follicle, and the pressure causes it to telescope into the spine itself, or, what is more generally the case, the spine bends sharply at the point of juncture of point and spine. Either procedure brings pressure to bear upon the large gland cell, forcing a small quantity of the poisonous cytoplasm into the wound. The same spine may be used repeatedly in this way, inflicting a wound in no wise less irritating than the first one, despite repeated use. While the heavy spines found in the *Eucleidæ* might possibly function a second time, those of the *Saturniidæ* are effective throughout the whole life of the spine.

Examination of the two Hemileucids showed an exactly similar type of apparatus, even to the two types of spines and their mode of distribution. Those of the *Hemileucae* are, however, smaller, shorter, and fewer in number than in *Automeris*. It is interesting to note that Caffrey, 1918, states that in *H. oliviæ* susceptibility to the effects of the poison increases from season to season.

CHEMICAL EXPERIMENTATION.

Work upon the chemical nature of the poisonous substance was disappointing. Except for the poison of *Euproctis chrysorrhea* and possibly *Cnethocampa pityocampa*, there are no records of success in any attempt to dissolve the toxic agent. Even in these cases where Tyzzer with water at 60° C. and using 70% ethyl alcohol got evidences of solubility the proportion of solute to solvent was so small as to make chemical work upon it impossible. Gilmer, 1923, upon *Hemerocampa leucostigma* tried in vain solvents of almost all natures. Upon the same insect and at the same time it was found that alkali decreased temporarily the toxic properties while acids increased them. Heat, both dry and moist, affect the poison by temporarily inhibiting its effects. Moist heat was far more effective, prolonged heating at 170° C. being necessary to effect the same change brought about by steam pressure of ten pounds for fifteen minutes. Both in the case of heat and dilute alkali the virulence returned after an interval of from forty-eight to seventy-two hours. Strong alkali dissolved the dried protoplasmic hair contents, after which the hairs were found to be non-irritant.

Oxidation with dilute potassium permanganate or very dilute potassium bichromate-sulfuric acid solutions were carried to completion and gave the same results. The loss of toxic properties in the latter cases almost parallel in degree the loss in protoplasmic contents. That there is no causal relation between the two is clearly indicated by the fact that very minute quantities of the poisonous cytoplasm is sufficient to produce a maximum reaction. The exact cause is probably due to a slow chemical change which happens to take place at about the same rate as solution of the protoplasm.

Microchemical tests were made with the assistance of Dr. E. D. Brown, of the Department of Pharmacology of the University of Minnesota, upon the very large gland cell of *Automeris io*. Since the heavily staining granules seemed to be a constant feature of all the poison cells, it was suspected that they actually represented the toxic material. The fact that the secreted poison in *Euproctis* also took the same stain heavily is added evidence.

No solution of these granules could be obtained. They gave no reaction with Millon's reagent, nor any xanthoproteic reaction. Molisch reaction was absent, as were reactions with the various alkaloidal reagents. The granules seemed inert to all chemical reagents attempted, except that they adsorb the haemotoxylin stains very heavily. This would point to a mucoid substance, but the failure to give a Molisch reaction for carbohydrate is negative evidence here. The very apt statement of Foote in his discussion of the poison of *Megalopyge opercularis* seems applicable to all the poisons so far worked upon: "The poison appears to be a venom, combined with protein vehicles, * * * ." That it is itself a protein, provided that the hypothesis that it is the heavily staining granules be true, seems unlikely from the failure to obtain any reaction with various protein reagents. The exceedingly minute quantities of material obtainable, the great difficulty in separating it from other cell contents, and finally its refractory nature make the probabilities of solving the problem of the chemical nature of the venom exceedingly remote.

ACKNOWLEDGMENTS.

Opportunity is here taken to acknowledge the aid received from various sources. To Dr. Wm. A. Riley, under whose

personal supervision the work has been carried out, is due especial thanks for his many suggestions and keen but kindly criticisms during the course of the investigations. To Drs. O. E. Oestlund, R. N. Chapman, E. J. Lund, R. A. Gortner, and Dr. E. D. Brown, all of the University of Minnesota, the writer's thanks also are due for timely criticism and assistance.

To Drs. Z. P. Metcalf, of North Carolina University, H. G. Dyar, of the National Museum, Washington, D. C., A. F. Burgess, Melrose Highlands, Mass., J. C. Faure, of the University of South Africa, Pretoria, S. A., and to Mr. C. P. Adamson, Raton, N. Mex., are due thanks for the material collected and sent to me.

Dr. O. A. Johannsen gave much needed assistance by the loan of Miss Kephart's preparations of *Euproctis chrysorrhea* from the Cornell University Department of Entomology's collection of material.

To Dr. J. R. Eyer is due thanks for the identification of such lepidopterous larvæ as were unknown.

Dr. N. C. Foote, of the Medical College of the University of Cincinnati, very kindly loaned me copies of the relatively inaccessible articles of Garcia and von Ihering, from which much valuable aid was obtained.

To the Journal of Parasitology I owe the permission to use the cut of Fig. 6, Miss Kephart's figure of the apparatus of *Euproctis chrysorrhea*.

Finally to all members of the Division of Entomology of the University of Minnesota the author's thanks are due for the aid in the collection of material and for their very cheerful submission as subjects for the disagreeable inoculation experiments made necessary by the work. For the latter especially, thanks are due to Mr. Arthur Hertig. Without the cooperation of the above and others the successful completion of the investigation would have been exceedingly difficult if not impossible.

SUMMARY.

1. The presence of poisonous properties among Lepidopterous larvæ is much more common than ordinarily supposed. There is good reason to hold the presence of urtication of any sort from larval hairs or spines as prima facie evidence of a true venomous nature, since histological examination has, without exception, shown a basis for this belief.

2. The structures involved in urtication are primarily of two well defined types; (a) the hair type, (b) the spine type. Each displays two well marked sub-types. The hair type displays (1) the primitive sub-type, (2) the modified sub-type. The spine type displays (1) the simple spine sub-type, (2) the branching spine sub-type.

3. The primitive hair type shows a single seta, morphologically little if any different from any other seta, except for the presence of a poison gland cell in immediate communication with its lumen; there being also the usual secreting trichogen cell. Usually the poison seta is somewhat shorter and stiffer than the non-toxic seta on the same individual.

4. The modified hair type shows a modification in which the main shaft of a branching seta has become lost by suppression, the individual branches becoming independently imbedded at their proximal ends in the old hair follicle. The chitin ring is lost with the main shaft, and the trichogen degenerates until it is impossible to demonstrate it with certainty. The follicle is supplied with the usual unicellular poison gland cell, which arms all the spicule-hairs of the follicle. Arming seems to be accomplished by an actual secretion of the poison, which passes through well marked channels to the various spicule tips.

5. The simple spine type shows a course of evolution from a type with a distinct hypodermal gland cell to one with the gland cell placed well within the lumen of the spine itself, and completely out of contact with the body hypodermis. Such spines have originated by an evagination of the body wall at the site of an originally toxic seta, the seta being carried on the apex of the spine where it shortens to form the penetrating tip or "point." The trichogen cell usually degenerates until it is distinguished with difficulty if at all.

In the simpler members the nucleus of the gland cell remains at the hypodermal level, although the cytoplasm extends throughout the lumen of the spine and fills the tip. In other members the gland cell has pulled out of the hypodermal level completely and into the lumen of the spine and pore-canal forming there a "bulb" within which will be found the nuclear portion of the gland. Again the cytoplasm fills the lumen and the tip.

6. The branching spine type displays a main axial spine with well defined substructures upon it. These substructures consist basally of sub-spines carrying "points", in the mid region of sub-spines carrying shortened setæ, and distally of setæ only. The terminal structure is always a well defined point. All alike are armed with gland cells, the various substructures intergrading one into the other.

In the branching spine type and in the somewhat intermediate *Automeris io* the gland cells are completely within the lumen of the spine, the greater part of the spine lumen being filled with ordinary body fluids only.

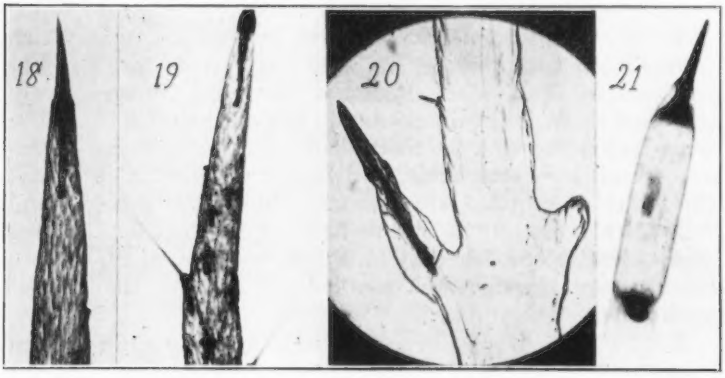


Fig. 18. Tip of Spine of *Euvanessa antiopa* Linn. Showing Point, Poison Gland and Trichogen Cell.
Fig. 19. Spine of *E. antiopa* Linn. Showing Setæ.
Fig. 20. Section of Base of Spine of *E. antiopa* Linn. Showing Sub-spine, Point and Gland Cell.
Fig. 21. Tip of Spine of *Automeris io* Fabr. (Point-bearer).

7. The two major types, hair and spine types, evidently bear a sequential relation, the spine following in development after the original appearance of the seta. The seta bears only a causal, not a phylogenetic relation, to the occurrence of the spine at that particular point.

8. The poison with the possible exception of that found in the modified hair type is not obtainable as a separate chemical entity, but the cytoplasm of the gland cell, carrying the poison as one of its constituent phases, functions directly as the venom carrying agent.

9. The poison is the product of a special gland cell, the gland being invariably unicellular no matter what the type of the penetrating organ. The gland cell is probably a sister cell of the trichogen cell, secreting the seta or spine point, the two probably having origin in the trichogen cell "anlage" before its differentiation from the hypodermis is carried out completely.

10. The composition of the venom, as well as the class of bodies to which it belongs is unknown. It is probably the granular material common to all the poison gland cells. This material is distinguishable by the fact that it takes all haemotoxylin stains particularly heavily. It is probably not a protein, but is, in all probability, adsorbed upon some protein molecule or group of molecules which are normal constituents of the gland cell cytoplasm.

BIBLIOGRAPHY.

Anderson, Jos., Jr. 1884. The Entomologist, 17 : 275.
Beille, L. 1896. C. R. soc. biol. de Paris, 547-547.
Berlese, A. 1909. Gli Insetti, 1 : 503-525.
Caffrey, D. J. 1918. Jour. Econ. Ent., 11 : 363.
Collins, C. W. 1915. Bull. U. S. D. A. 273, 1915: 1-23, Washington, D. C.
Eltringham, H., 1913. Trans. Ent. Soc. Lond. Pt. 3: 423-427.
Fabre, J. H. (1916). Life of the Caterpillar (Eng. transl.) Chaps. 4-7.
Foote, N. C. 1922. Jour. Exp. Med. 35: No. 5; 737-753.
Fracker, S. B. 1915. Ill. Biol. Monographs, 2: No. 1.
Garcia, E., 1910. Los Gusanos Urticantes del Valle de Cauca, Cali. (Privately printed). Cali, Valle de Cauca, Columbia.
Gilmer, P. M. 1923. Jour. Parasit. 10 : No. 2; 80-86.
Goossens, Th. 1881. Ann. Soc. Ent. France, (6) 4 : 231-236.
1886. Ann. Soc. Ent. France, (6) 4 : 461-464.
Gorka, A. von, 1907. Math. Nat. Ber. Ungarn, Bd. 21 : 233-234.
Holmgren, E. 1896. Svenska Ak. Hendl. 27 : No. 4.
1896. Ent. Tidsk. 17 : 81-85.
Ihering, R. von. 1911. Ann. Paulistas med. e cirug. 3 : 129-
Ingenitsky, I. 1897. Hor. Soc. Ent. Ross. 30 : 129.
Keller, C. 1883. Kosmos Bd. 13 : 302-306.
Kephart, Cornelia. 1914. Jour. Parasit. 1 : 93-103.
Knight, H. H. 1922. Jour. Parasit. 8 : 133-135.
Laudon. 1891. Arch. fur Path. Anat. u. Physiol. Bd. 125.
Mills, R. G. 1923. China Med. Jour. 38 : No. 5; 351-371.
Morren, C. F. A. 1848. Bull. Acad. Brux. F. 15, 2 : 132-144.
Packard, A. S. 1895. Proc. Am. Phil. Soc. 32 : 275-292.
Riley, W. A. 1913. Science N. S. 37 : No. 958; 715-716.
Scudder, S. H. 1889. Butterflies of the Eastern United States and Canada. 1 : 400-401.
Tyzzer, E. E. 1907. Jour. Med. res. Boston, Mass., 16 (N. Ser. 11): 43-64.
Will, Fr. 1848. Froriep Notizen. 1848.

INSECTS ASSOCIATED WITH SPIDER NESTS.*

MARY AUTEN
Randolph-Macon Woman's College, Lynchburg, Va.

INTRODUCTION.

Insects may be associated with spiders in a variety of ways. Some are external parasites on the spiders themselves, the larvæ clinging to the bodies and deriving nourishment therefrom; some are internal parasites, living within the bodies of the spiders; others lay their eggs in the freshly made nests of the spiders, and the larvæ, when hatched, feed indiscriminately upon the eggs, then pupate and remain in the cocoon, being protected by it until they reach the adult stage; another type is the egg parasite, where the insect egg is laid within the egg capsule of the spider and there obtains enough nourishment from this one egg to supply its needs until it becomes adult; still other insects wander around from nest to nest feeding on the contents of various nests, but not remaining in any one nest in particular and not pupating in the nest, but near to it; this sort being predatory on the young spiders. The original observations recorded in this paper deal only with those insects which are associated in some way with the egg cocoons of the spiders.

Since Dr. L. O. Howard's work in 1890–'92, only scattered items have been added to our knowledge of this subject. The present paper is an attempt to bring together these items and to add to them the result of recent observations made by the writer.

ACKNOWLEDGMENTS.

It is a pleasure to express my gratitude to Dr. C. H. Kennedy, who directed this work and to others of the Department of Zoology and Entomology for valuable suggestions; also to Dr. A. B. Gahan, of the U. S. National Museum, for describing the three new species found and to those outside of the department who determined specimens and aided in various ways.

* Contributation from Department of Zoology and Entomology of Ohio State University, No. 80.

Part I. Original Work Done by the Writer on Spider Nests at Put-In-Bay, Ohio.

A. The species of spiders whose nests were studied.

The Put-In-Bay region is especially favorable for this sort of a study because of the great number of spiders found there. This abundance, however, varies from year to year. In the summer of 1922 the number of spiders had decreased to a great extent at South Bass Island, where they were so numerous in 1921, while at East Sister Island they were very abundant in 1922. Apparently there is a rise and fall from year to year of the parasitism here, as there is in insects.

The collection of the nests was begun the latter part of June and continued until the latter part of July, 1921. About five hundred and fifty nests were collected; the majority (three hundred and ninety) was of *Philodromus canadensis* Emerton.

The species of spiders which were especially numerous and whose nests were collected were:

(1) *Philodromus canadensis* Emerton. The small pure white nests of this crab spider were made on the twigs of the red cedar trees on the south and west shores of South Bass Island and on Gibraltar Island.

(2) *Epeira sclopetaria* Clerck. The nests of the gray cross spider were also on the cedar trees, but were quite different from the ones just mentioned, being a little larger and of yellowish color.

(3) *Aranea frondosa* Walck. The nests of this spider were found in the crevices around the doors, windows, and rafters of the porches of the deserted houses on Ballast Island. Nests of this same spider were also collected from a deserted hut near the carp pond at West Harbor. Here the rafters on the roof of the small porch protected most of the nests, while some were in the crevices of the window frames. The crevices between the bricks of the Put-In-Bay Fish Hatchery, as well as the window frames, supplied places for the spiders' nests. A few nests were also gathered from the cottage in which we lived and from the engine-house nearby.

(4) *Enoplognatha marmorata* Hentz. A few very interesting little orange colored nests were found under logs in Cave Woods, South Bass Island. The spider was not taken with

these nests, but J. H. Emerton, to whom I sent one for identification, thinks "it probably belongs to Enoplognatha marmorata, if not to that to some Steatoda." This was the only place where they were found and they proved to harbor a parasite which is quite distinct from any other. Probably the breeding season was too far gone before they were discovered, to find very many of them.

(5) *Dolomedes tenebrosus* Hentz. Two nests were collected in 1921 and three in 1922. There were no parasites found in any of these nests.

B. NOTES ON THE SPECIES REARED.

Chalcidoidea.

The following species of this super-family were reared:

Genus? species? (Cleonymidæ). Eight specimens of this family which could not be placed generically were reared from six of the nests of *Philodromus canadensis* Emerton. Two nests had two specimens, and the other four, one each. These are deposited in the U. S. National Museum. Other species reared from these same nests were *Tetrastichus philodromi*, *Chrysopa interrupta*, and *Eupteromalus cognatus*.

Dibrachys boucheanus Ratz. Thirty-eight specimens of this species were reared from the nests of *Philodromus canadensis* and from the nests of *Aranea frondosa*. The highest number to a nest was six and the lowest one. It probably is a hyperparasite, although this was not determined. Other species reared from these same nests were: *Oscinis halterata*, *Sarcophaga hinei*, *Eupteromalus cognatus*, *Tetrastichus philodromi*.

Eupteromalus cognatus Gahan. Ten specimens were reared from one nest and six from another of *Epeira sclopetaria*. Ten other specimens were reared from nests of *Aranea frondosa* and *Philodromus canadensis*. These are deposited in the U. S. National Museum.

Tetrastichus philodromi Gahan. These were reared from the nest of *Philodromus canadensis*. One hundred sixty-two of the three hundred nests collected were parasitized with this species, the average number of individuals to the nest being seventeen, the greatest number to any one nest being seventy-four and the least number one. The contents of the spiders' eggs were eaten, leaving only tiny bits of dried shells in the

nests. This also is probably a hyper-parasite. Other insects reared from these same nests were: *Cleonymidæ* g. sp., *Oscinis halterata* Mall, *Dibrachys boucheanus* Ratz, and *Hemiteles* sp. *Tetrastichus philodromi* is described by G. A. Gahan in Proc. U. S. N. M. No. 2517, Vol. 65, Art. 4, p. 18, 19, 1924.

Proctotrypoidea.

Baeus rotundiventris Gahan. Eleven orange colored nests, probably belonging to *Enoplognatha marmorata*, were found under rotten logs in Cave Woods, South Bass Island. Three of the eleven nests were parasitized with two species of *Baeus* (small wingless flea-like creatures), fifty-five individuals in one nest and at least as many in the other two. These are true egg parasites, the young living inside the egg and escaping as an adult through the lid-like opening of the neatly cleaned egg capsule. Described by Gahan, Proc. U. S. N. M. No. 2517, Vol. 65; Art. 4, p. 20, 21, 1924.

Ichneumonoidea.

(*Pezomachus*) *Gelis flavicinctus* Ashm. Two specimens of this wingless, ant-like insect were collected from the nests of *Aranea frondosa*.

Hemiteles sp. (Members of this genus are said to be exclusively hyperparasites). Four specimens were reared from the nests of *Philodromus canadensis* and *Aranea frondosa*. *Tetrastichus philodromi* Gahan was the only other species reared from these nests.

Tromatobia zonata Davis. Five specimens were reared from nests which very probably belonged to *Epeira sclopetaria*, three from one nest and two from another. No data was obtained concerning the one nest as it was brought in by another student before work was begun on this problem, but the other nest was taken from a cedar tree. *Oscinis halterata* was also reared from these nests.

Phoridæ.

Aphiochæta epeira Brues. Thirteen specimens were reared from the nests of *Epeira sclopetaria*, the largest number to a nest being nine.

Oscinidæ.

Oscinis halterata Mall. Eighty specimens were reared from the nests of *Philodromus canadensis*, *Epeira sclopetaria*, and *Aranea frondosa*. The largest number to a nest was six.

Pseudogaurax anchora Loew. Four specimens were reared from the nests of *Aranea frondosa*, one nest having three specimens in it.

Sarcophagidæ.

Sarcophaga hinei Aldrich. Twenty specimens were reared from the nests of *Philodromus canadensis*, *Epeira sclopetaria* and *Aranea frondosa*. The largest number to any one nest was four and the least two. This species was taken several years ago by Prof. J. S. Hine and described by J. M. Aldrich; however, it had not been reared and its habits were not known.

Chrysopidæ.

Chrysopa interrupta Schneider. Three specimens were reared from three of the nests of *Philodromus canadensis*. The insect's cocoon was not in the spider's cocoon but very near to it in all three cases. Probably the larvæ roved from nest to nest, feeding on the eggs of no one nest in particular but on several different ones, then pupated nearby. Concerning this species Prof. R. C. Smith, who kindly identified the specimens, wrote: "This species is rare everywhere, and practically nothing is known about it. Banks (Ent. Soc. Wash. Proc. 1915) found it hibernating as an adult. Fitch described it in his first report, 1856, as *Chrysopa tabida*, but Banks places this name in synonomy. I have taken this species in New York, Virginia, Wisconsin, Ohio and Kansas, chiefly by beating trees and bushes or by sweeping. I have thought for several years that this species and *Chrysopa rufilabris* Burm. integraded, but your discovery and the uniformity of these four specimens are against that view. The species is really a very light *C. rufilabris* but this light straw yellow color appears in my specimens. These four and Banks' specimens seem to be quite uniform. I have never reared this species. Several times I thought I had the larvæ but most frequently C. rufilabris adults resulted. On the other hand, I have reared adults from what were apparently C. rufilabris larvæ which resulted in adults indistinguishable from *C. inter-*

rupta. Hence I stated in my Chrysopid paper that those two specimens were the most puzzling specimens seen. There is very little, indeed about this species in literature or in my forthcoming paper." These larvæ which were taken at Put-in-Bay, were all reared without any careful study of them being made, and so the writer is not able to add any further data concerning the life history of this species.

Reduvidæ.

Acholla multispinosa DeGeer of this family was found wandering about over the nests of *Philodromus canadensis*. The exact relationship to the nests was not determined, but since it was seen in several cases it was probably a predator of the eggs or of the young spiders.

Dermestidæ.

The larvæ of the beetle, *Trogoderma ornatum* Say, were found feeding on the eggs in the nests taken under the bark of trees. Later in the summer and in the early part of the winter the larvæ destroyed many of the nests and even ate into the capsules containing the reared insects.

Ptinidæ.

Two specimens of the species *Ptinus fur* Linn. were found in the nests of *Aranea frondosa*, but probably even then only by accident, and probably they were not feeding on the eggs of the spider.

(Besides these insects which were reared there were many mites, which I did not attempt to study, which got into the nests and destroyed some of the specimens).

C. METHODS USED.

Since the type of insects which were apt to be parasites was not known an attempt was made to rear insects from as many nests as possible. Many of the most common spiders were collected and spiders were always taken with the nests when possible.

The nests of *Philodromus canadensis* and *Epeira sclopetaria* were clipped from the trees with small scissors and the nests of

Aranea frondosa and *Enoplognatha marmorata* were torn from their shelters with forceps. A spider when taken with the nest was placed in 80% alcohol and labeled according to the nest label. The nests were placed in individual vials plugged with cotton, and these placed in Marx trays, where they were allowed to remain until the insects emerged. When the insects were reared they were killed and placed in number three gelatin capsules for further study. Mites and dermestid beetle larvæ were very serious pests. Some of the hymenopterous larvæ which over-winter were killed by the mites. In their natural habitat most of the nests were in the shade and it is advisable to keep them from the sun in the laboratory. Over-wintering forms which were not attacked by the mites probably died from lack of moisture. Yuasa found that in rearing saw flies, it was necessary to bury pupating forms in the ground in order to insure uniform moisture, and perhaps some such method would help keep these in the right condition.

SUMMARY.

To summarize, it can be said that the Put-in-Bay region was ideal in 1921 for the study of spider nests and their associates, (there are four types of spiders which are in great abundance and no doubt many more would be found if they were sought); that insects associated with spider nests are of three types: parasites, predators and accidental inhabitants of the nests; that all the kinds of nests studied except *Enoplognatha marmorata* and *Dolomedes tenebrosus* are attacked to some degree by hymenopterous, dipterous and coleopterous insects. The following table summarizes the relationships among the species studied at Put-in-Bay:

Aranea frondosa	Hymenop.	Pteromalidæ	Dibrachys boucheanus
		Ichneumonidæ	Gelis flavicinctus
			Hemiteles sp.
	Diptera	Oscinidæ	Oscinis halterata
			Pseudogaurax anchora
		Sarcophagidæ	Sarcophaga hinei
	Coleop.	Dermestidæ	Trogoderma ornatum
		Ptinidæ	Ptinus fur
Enoplognatha marmorata	Hymenop.	Proctotrypidæ	Bæus americanus
			Bæus rotundiventris
Epeira sclopetaria	Hymenop.	Pteromalidæ	Eupteromalus cognatus
		Ichneumonidæ	Tromatobia zonata
	Diptera	Oscinidæ	Oscinis halterata
		Phoridæ	Aphiochæta epeira
		Sarcophagidæ	Sarcophaga hinei
	Hemiptera	Reduvidæ	Acholla multispinosa
	Coleop.	Dermestidæ	Trogoderma ornatum
Philodromus canadensis	Hymenop.	Cleonymidæ	Genus? sp? (n.g., n.sp. Gahan
		Pteromalidæ	Dibrachys boucheanus
		Tetrastichidæ	Tetrastichus philodromi
		Ichneumonidæ	Hemiteles sp.
	Diptera	Oscinidæ	Oscinis halterata
		Sarcophagidæ	Sarcophaga hinei
	Neuroptera	Chrysopidæ	Chrysopa interrupta
	Hemiptera	Reduvidæ	Acholla multispinosa

This table shows that a specific insect does not occupy a specific host nest, but that one nest may be parasitized by more than one species. Also that the same insect species may parasitize several different kinds of nests.

PART II.

A list of the insects reared from nests of the spiders in the Put-in-Bay region in addition to those cited in literature as associated with North American spider nests.

PARASITE	HOST NEST	REFERENCE
Chalcidoidea		
Cleonymidæ		
Genus? species?	Philodromus canadensis	Put-in-Bay
Entodontimidæ		
Chrysocharis banksii	Argiope cophinaria	McCook '93
Chrysocharis pikei	Argiope cophinaria	McCook '93
Holcopelte nitens, How	Epeira sp	Howard '92
Mestocharis wilderi, How	Epeira riparia	Howard '92
Eupelmidæ		
Eupelmus drassi How	Drassus sp	Howard '92
Eupelmus piceus How	Argiope argentata	Howard '92, Davidson '96
Pteromalidæ		
Dibrachys boucheanus Ratz	Philodromus canadensis	Put-in-Bay
	Aranea frondosa	
Eupteromalus cognatus Gahan	Aranea frondosa	Put-in-Bay
	Epeira sclopetaria	Put-in-Bay
	Philodromus canadensis	Put-in-Bay
Pteromalus sp	Epeira sclopetaria	Put-in-Bay
Tetrastichidæ		
Tetrastichus banksii How	Epeira sp	McCook '93, Howard '92
Tetrastichus philodromi Gahan	Philodromus canadensis	Put-in-Bay
Proctotrypoidea		
Proctotrypidæ		
Acoloides bicolor Ash		Ashmead '93
Acoloides emertonii How		Howard '91, Ashmead '93
Acoloides howardii, Ash		Ashmead '93
Acoloides melleus Ash		Ashmead '93
Acoloides saitides, Ash. How	Saitis pulex	Howard '90, '02
	Phidippus morsitans	Ashmead '93
Acoloides seminiger Ash		Ashmead '93
Acoloides subapterus Ash		Ashmead '93
Acolus Xanthogaster Ash		Ashmead '93
Acolus zabriskiei, Ash		Howard '91, Ashmead '93
Bæus haliday Ash		Ashmead '93
Bæus americanus How	Epeira sp	Howard '90, '92, Ashmead '93
Bæus clavatus Proc., Ash		Ashmead '93
Bæus minutus Ash		Ashmead '93
Bæus niger Ash		Ashmead '93
Bæus picens Ash		Ashmead '93
Bæus americanus How	Enoplognatha marmorata	Put-in-Bay
Bæus rotundiventris Gahan	Enoplognatha marmorata?	Put-in-Bay
Ichneumonoidea		
Ichneumonidæ		
Clistopyga nigrifrons Cush		Cushman '21
(Pezomachus) Gelis flavicinctus Ashm	Aranea frondosa	Put-in-Bay
Hemiteles davidsonii Ash	(a latigrade spider)	Davidson '96
Hemiteles drassi How	(a Drassid spider)	Howard '92
Hemiteles micarivora How	Micaria sp	Howard '92

PARASITE	HOST NEST	REFERENCE
Hemiteles prosthesinæ How.	Prosthesima furcata	Howard '92
Hemiteles sp.	Philodromus canadensus	Put-in-Bay
	Aranea frondosa	Put-in-Bay
Pezomachus dimidatus Cresson.	Epeira sp.	McCook '93
Pezomachus gracile Forster.	Epeira cavatica	McCook '93
Tromatobia zonata Davis.	Epeira sclopetaria	Put-in-Bay
Pezomachus micariæ How.	Micaria sp.	Howard '92
Pezomachus n. sp.	Argiope cophinaria	McCook '93
Pezomachus obesus Brues.		Brues '10
Pezomachus obscurus Cress.	Micaria sp.	Cresson '72
Pezomachus proximus Forster.	Argrocea brunnea	McCook '93
Pezomachus unicolor Cress.		Cresson '72
Pimpla aquilonia Cress.	Argiope argentata	Cresson '70
	Argiope cophinaria	Davidson '96
	Epeira sp.	Howard '91
		McCook '93
Pimpla conquisitor Say		Brues '21
Pimpla inquisitor Say.	Argiope riparia	Wells '89
Pimpla japonica Ashm		Howard '91
Pimpla rufopectus Cress.	Argiope riparia	Cresson '70
	Argiope cophinaria	Keobele '87
		Davidson '90
		McCook '93
Pimpla scriptifrons Cress.	Argiope riparia. Cresson '70,	Koebele '87
	Argiope cophinaria. Davidson '90,	McCook '93
Polyspincta theridii How.	Theridium sp.	Howard '92
Diptera		
Phoridæ		
Aphiochæta epeiræ Brues.	Epeira sp.	Brues '03
	Epeira sclopetaria	Put-in-Bay
Cyrtidæ		Cole '19
Oscinidæ		
Gaurax araneæ Coq.	Epeira angulata	Coquillet '96
Gaurax lancifer Coq		Coquillet '96
Oscinis halterata Mall.	Epeira sclopetaria	Put-in-Bay
	Aranea frondosa	Put-in-Bay
	Philodromus canadensis	Put-in-Bay
Pseudogaurax anchora (Loew).	Aranea frondosa	Put-in-Bay
Siphonella oscinæ (Fall.)		Coquillet '98
Sarcophagidæ		
Sarcophaga davidsoni (Coq.).	Phidippus opifex. Coquillet '93,	Davidson '93
Sarcophaga hinei Aldrich.	Philodromus canadensis	
	Epeira sclopetaria	
Coleoptera		
Dermestidæ		
Trogoderma ornatum Say.	Aranea frondosa	Put-in-Bay
	Epeira sclopetaria	Put-in-Bay
Ptinidæ		
Ptinus fur Linn.	Aranea frondosa	Put-in-Bay
Neuroptera		
Chrysopidæ		
Chrysopa interrupta Schneider.	Philodromus canadensis	Put-in-Bay
Hemiptera		
Reduvidæ		
Acholla multispinosa DeGeer.	Philodromus canadensis	Put-in-Bay
	Epeira sclopetaria	Put-in-Bay

BIBLIOGRAPHY.

This is as complete a list of American articles as the writer could make and also includes a few foreign articles which were found incidentally.

Aldrich, J. M. 1905. Bibliography. Catalogue of American Diptera.
1916. Sarcophaga and its allies. Say Foundation Mon. I.
Ashmead, W. H. 1893. Bull. U. S. Nat. Mus. XLV, 169–180.
Bignell, H. C. 1893–94. Ann. Rept. and Trans. Plymouth (England) Inst. XI, 276–294.
Brues, C. T. 1903. Trans. Amer. Ent. Soc. XXIX, 358–359.
1910. Bull. Wisc. Nat. H. Soc. VIII, 71–72.
Cole, F. R. 1919. Trans. Amer. Ent. Soc. XL, 1–79.
Coquillet, D. W. 1893. Insect Life, V, 24, Also VI, 268.
1898. U. S. Div. of Ent. Bull. No. 10 N. S., 70–79. Proc. U. S. Nat. Mus. XXII, 265.
Cushman, R. A. 1920a. Proc. U. S. Nat. Mus. XLVII. No. 2315, p. 379–396.
1920b. Proc. U. S. Nat. Mus. XLVIII, No. 2326, 336.
1920c. Proc. U. S. Nat. Mus. LVI, No. 2399, 1–14.
Cresson, E. T. 1870. Trans. Amer. Ent. Soc. III, 145–148.
1872. Can. Ent. IV, No. 2, 62–64.
Davidson, A. 1894. Insect Life VI, 268–269.
1896. Ent. News VII, 319–320.
***Dalla Torre, K. W. von.** Catalogue of Hymenoptera V, 512.
Girault, A. A. 1915. Ent. News XXVI, 221.
Gahan, A. B. 1924. No. 2517, Proc. U. S. Nat. Mus., Art. 4, pp. 1–23.
Hasselt, A. W. M. Van. 1891. Over de Parasieten den spinnen. Tijdschrift voor Entomologie.
Howard, L. O. 1890a. Insect Life II, 269–270.
1890b. Insect Life II, 359.
1891. Insect Life IV, 202.
1892. Proc. Ent. Soc. Wash. II, No. 3, 290–303.
Koebele, A. 1887. Insect Life, III, 461.
***Kryger, J. P.** 1910. Snylterei Edderkoppeaeg. Ent. Meddels. Kiobenhaum III, 280–285.
McCook, H. C. 1893. Spiders and their spinning work. II–III.
Patton, Wm. H. 1894. Ent. News. V, 118–119.
***Ratzburg, J. T. C.** 1884. Ichneumon of forest insects. Die Ichneumon der Forstinsecten in forstlichler und entomologischer Beziehung, also Anhang, zur Abbildung und Beschreibung der Forstinsecten Berlin. Nicolari. (Extensive work in several volumes).
Rohwer, S. A. 1920. Proc. U. S. Nat. Mus. LVII. No. 2385, 379–396.
***Schwangart, F.** 1906. Zs. Wiss. Insektenbiol, Husum. II, 105–107.
***Shannon, R. C.** 1914. Proc. Ent. Soc. Wash. XV, 162.
Webster, F. M. 1894. Ent. News V, 146–147.
Wells, H. C. 1889. Insect Life I, 324.
***Wilder, B. G.** Proc. Amer. Assoc. Adv. Science. XX pt. 2, 257–263.

Note.—References marked (*) were not seen by the writer.

APPENDIX.

An incomplete bibliography of the literature concerning external and internal parasites of spiders.

Ashmead, W. H. 1895. Insect Life VI, 259–260.
***Butler, A. G.** Entomologist XV, 216.
Cushman, R. A., and **Rohwer, S. A.** 1920. Proc. U. S. Nat. Mus. LVII No. 2315, 379–396.
Cushman, R. A. 1920. Proc. U. S. Nat. Mus. LVIII, No. 2326, 18.
Emerton, F. H. 1890. Psyche V, 404.
Howard, L. O. 1888. Insect Life I, 42.
1890. Psyche V, 404.
1892. Ent. Soc. Wash. II, 292.
***King, J. L.** 1916. Ent. Soc. of Amer. Annals IX, 309–321.
***Menge, Auton.** 1863–1866. Schiftd Danzig Nat. Gesel. N. Folge 1, 37.
***Montgomery, T. H.** 1903. Proc. Acad. Nat. Science, Phila. 55–68.

Note.—References marked (*) were not obtained.

WING VENATION OF THE BUPRESTIDÆ.

HENRY G. GOOD
Alabama Polytechnic Institute

INTRODUCTION.

As a subject for systematic and phylogenetic study, the wing-venation of the Coleoptera is as yet undeveloped. Few workers have gone very far in homologizing the veins and in coming to definite conclusions. The reasons for this are several. The removal of the wings after the specimens have been relaxed is so difficult that the specimens are very apt to be ruined, a very important consideration when one is working with the rarer specimens. The venation is so complicated, due to the folding of the wings, that the subject has been avoided as much as possible. Among the workers, however, who have made a study are Adolph, Redtenbacher, Ganglbauer, Kolbe, Lameer, Graham and Forbes.

Kolbe, the first worker, adopted an idea of an alternation of concave and convex veins. Redtenbacher (Ann. d. K. K. Hofm., 1886), Kempers (Tijid. voor Ent., 1899-1901) and Kolbe (Archiv fur Naturg., 1901) followed the same idea of convex and concave veins and did not consider tracheation. They worked on the order as a whole, and gave many illustrations for most of the families. Their work puts one in touch with the characters of the wings and the types of venation in the Coleoptera from the most primitive to the more highly specialized forms in which the venation is very much reduced. Among the latter, it is very hard to definitely homologize the veins. Woodworth (Univ. Calif. Publication, Ag. Exp. Sta., Tech. Bull.-Entom.-QOPY. v. 1: No. 1) also used this theory but dwells upon the folding of the wings, believing that the veins have adapted themselves to the folding of the wing rather than that the folding has developed later, following the lines of least resistance.

Then follow Lameer and Ganglbauer, who stand out prominently. They agree that Cupes shows the most primitive form of venation, and that the Serricornia stand next with the Lampyridæ as the lowest of this group. Upon an examination of their wings, it is found that the folding is simple, for it is

more apical and the veins are not so disrupted as in the more highly developed forms. This condition also gives a better chance to study the venation.

Graham (Annals Ent. Soc. Amer., 1922) uses a good series of illustrations and shows a hypothetical type of venation. Had he used the tracheation as a basis of the study, he would very likely have worked out a very different hypothetical wing from the one that he has used. His reason for not using the tracheation is that he did not consider it stable enough to be of any systematic value.

Forbes (Annals Ent. Soc. Amer., 1923) bases his ideas largely upon the tracheation and on the basal sclerites. It is his system that the writer is using in this paper. From the position of the veins and the tracheation, it is found that there is a forward migration of the veins and increase in their number in the anal region. Forbes has also worked out a hypothetical type of venation based upon the venation of Cupes, Hydrophilus and Cebrio. His studies of the pupal pads confirm the results obtained by an examination of the mature wings.

ACKNOWLEDGMENTS.

Before working on this problem, the writer had long been curious as to what extent the venation of the Coleoptera might prove to be of systematic value. It was through Dr. W. T. M. Forbes of Cornell University that his interest was stimulated to undertake a study of the venation of the Buprestidæ. He therefore wishes to thank Dr. Forbes for the amount of time and invaluable aid that he gave in the technique of wing-extraction and in the homologizing of the veins. He also wishes to thank the members of the entomological staff of Cornell University for their help and for the loan of specimens from the collection. Mr. A. J. Mutchler of the American Museum, Mr. C. W. Leng and Mr. W. T. Davis of Station Island, Mr. C. J. Schaeffer of the Brooklyn Museum, Dr. H. S. Barber of the National Museum, and Dr. E. C. Van Dyke of the University of California, all aided by loaning specimens of the rarer genera. To these, the writer is very grateful.

GENERAL DISCUSSION.

The students of the wing-venation of the Coleoptera have hitherto been concerned with the venation of the order as a whole and have not dealt with the families in detail. The present paper results from the study of the venation of a single family, made with the intent of ascertaining the existence of any facts that might be of taxonomic value. The writer will try to establish the following facts which to him seem to be the most interesting and important, namely:

1. The characters of the venation.
2. The stability of the venation.
3. The phylogeny of the Buprestidæ as indicated by their wing-venation, and a reconciliation of their present classification therewith.

1. Characters of the Venation.

The Buprestidæ may be separated from the other families of the Coleoptera by having a combination of three outstanding characters: (1) The beginning of the radial sector and the beginning of the medial vein are approximately opposite each other and may or may not be connected by a cross-vein. (2) There are two unattached divergent veins in the apical portion of the wing. (3) The first two branches of the second anal vein are free from the third branch. Specialization has brought about a great many changes in the venation of the wings, giving rise to generic characters, but these characters remain constant. Reduction also occurs; for example, the first anal vein, or the second branch of the second anal vein or both may be absent. The fourth anal vein may also be absent.

(a) Tracheation.

The tracheation of the Coleoptera, although heretofore largely ignored is of the utmost importance in properly interpreting the homologies of the veins. Comstock and Needham base their work largely upon the tracheation of the immature wings, and for the same reason the tracheation in the Coleoptera can easily be used as they show to good advantage. In the pupal pad of Chrysobothris femoratus (Oliv) (Fig. 1), which is one of the more specialized forms, we find that the tracheæ show very plainly and may well serve as a representative of the family. The

costal trachea is not present but is found in the pads of other families of the Coleoptera (Forbes). The subcostal trachea is strong and extensively branched, and extends to the border of the wing. The radial trachea is much smaller and less extensively branched. The one principal branch that is given off is apparently that of the radial sector. Media is quite prominent, branching apically and approximating the cubital trachea which is also extensively branched, although the cubital vein is single. The first anal trachea is slightly branched, approximating the cubital trachea. The second anal trachea is distinctly three branched as in the adult wing. The third anal trachea is a single unbranched trachea and the fourth is more or less rudimentary.

Figure 2 represents an adult wing with the veins in white and the tracheæ in black so as to show the relation of the two. The basal connection of the first and the fourth anal trachea and the costal trachea was not seen.

(b) Adult Wing.

In the mature wing, which in most cases retains its tracheæ, the venation corresponds quite closely to the tracheation just explained. The costal vein is normal, following along the anterior border of the wing but no trachea has been found in this vein in any of the wings of the Buprestidæ examined.

Subcosta is a strong, unbranched vein, uniting either with costa or with radius. When it unites with costa, it often abruptly curves toward the margin of the wing. When uniting with radius the two veins unite with costa approximately opposite the first radial cross-vein. In only one genus, Taphrocerus, (Fig. 37) do they run parallel to, and remain distinct from, the costal vein.

Radius. This vein is strong and branched. The first branch is parallel with the anterior margin of the wing. The basal portion of the radial sector (Rs) has atrophied. It is connected to the first branch of radius by two cross-veins. In more primitive forms, these cross-veins are parallel with the anterior margin of the wing. These two cross-veins also enclose a cell which will be spoken of as (cell R_1), (Radial cell), although it is the cell $2R_1$. The radial sector is divided into two portions; one is connected with the first branch of the radial vein by the two cross-veins while the second is unattached and is in the apical part of the wing. In the species of the genus Polycesta (Fig.

27), the relation of the two branches of the radial sector is well shown. The unattached vein is very likely R_2 and R_3 fused, while the remaining branches have become atrophied.

Media. The basal portion of the medial vein is likewise lost. The beginning of the medial vein is opposite that of the radial sector and it unites with the single cubital vein. The free portion of media, termed the "medial recurrent," is variable in length, and its length in porportion to the fused portion is a good generic character, as it is constant within a genus. The median trachea which is in most cases easily followed in the adult wing arises with radius, passes over to cubitus which it follows for a short distance. Again separating, it passes through the membrane of the wing and enters the median vein. Between the unattached section of Rs and the fused apical portion of media and cubitus, lies a second unattached vein. The fact that a branch of the median trachea sometimes enter this vein (*Euchroma gigantea* L.) confirms the suspicion that it is a branch of media. It is probably the fused first and second branches of the median vein, in which case M_3 and M_4 are fused with the cubital vein.

Cubitus. Cubitus is an unbranched vein, extending from the base of the wing and uniting apically with M_3 and M_4. It is a strong vein and is straight curving only to meet the median vein.

Anal system of venation. This is the only portion in the wing of the Coleoptera in which there is an addition instead of a reduction of veins. In the more primitive forms, there are four distinct veins in this system, of which two are branched and two are not, the total number of branches being seven.

The first anal vein (Pl. 1, Fig. 10) has lost its basal portion but is instead attached to the cubital vein by the cubito-anal cross-vein (cu-a). It then fuses with the first branch of the second anal vein for a short distance and then separating from it, extends to the margin of the wing. Its trachea is plainly seen arising at the base of the wing and entering the base of the vein. This vein may be continuous as in Trachykele (Fig. 11); interrupted as in the majority of the genera; or it may be absent as in the leaf-mining genera (Brachys, Taphrocerus, and Pachyscelus).

The second anal vein is three branched. The first two branches are normally attached to each other but have lost

their attachment to the third branch. The first is always present while the second branch may be rudimentary or absent. The only case in which the second branch is not attached to the first branch is in the genus Agrilus (Fig. 45). The third branch is usually connected to the first branch of the third anal vein by a crossvein. The exceptions to this are in Taphrocerus, some species of Brachys and in the genus Acmæodera. Distally, these two veins may unite to form a cell (2d-2dA). This is the so-called "wedge-cell" of the European writers. Taxonomically, these two veins are very important in respect to the relative lengths of the fused portion to the length of the cell, or when not fused to the degree of their divergence.

The third anal vein is two branched. The first branch is connected to the third branch of the second anal vein, although as above stated, the branches of the third anal vein may not be united. The second branch extends to the margin of the wing and usually is straight. The trachea is not so commonly found in this vein as in most of the others. In the genus Acmæodera, the union of the first branch of the third anal vein with the third branch of the second anal vein is at the base of the wing.

The fourth anal vein is quite strong in the more primitive forms, rudimentary in the leaf-mining genera and absent in those forms that lack cell R_1. No trachea has been found in this vein in any of the wing of the Buprestidæ studied.

Cross-veins. The maximum number of cross-veins found in the wing of the Buprestidæ is five. These are: two radial cross-veins, a radio-medial, cubito-anal, and 2dA-3dA$_1$ cross-vein. As explained above, the radial cross-veins connect the radial sector with the first branch of the radial vein. As these two cross-veins complete the radial cell, they are naturally absent when the radial cell is absent.

Taxonomically, the radio-medial cross-vein (r-m) is the most important as it remains constant within a genus. That is, its position in relation to the first radial cross-vein is the same. It may be distad, opposite of the radial cross-vein or it may be absent according to the genera. The phylogenetic trend is for the cross-vein to advance basad and to disappear in that way.

The cubito-anal cross-vein is usually present and connects the two veins at about one-third the length of the wing. This vein also has a tendency to atrophy, often only appearing as a spur.

The cross-vein connecting the second and third anal vein is the most posterior, varying in length and usually oblique in position. This cross-vein is present in most of the genera of the Buprestidæ, although it is barely visible in the forms that are lightly chitinized. As already mentioned, it is absent in the genus Acmæodera and in some of the leaf-mining genera.

(c) Folds and Folding.

Woodworth's contention that the veins have become modified in order to adapt themselves to the manner of folding, rather than that the folding was a later adaptation following the lines of least resistance, is unfounded. This is proven by the fact that many genera have a similar venation but have a very different system of folding. For example, the genera Melanophila and Buprestis have a quite similar type of folding. Melanophila (Fig. 7) has a very simple type of folding but Buprestis (Fig. 4) has numerous secondary folds. This is like wise found by comparing Chrysobothris and Actenodes. There is, however, a general type of folding found that is characteristic of the family except for the leaf-mining genera which have a complex system of secondary folds in the apical region.

There are at least four definite folds in the wings of the Buprestidæ, as in all the Coleoptera. Three are in the discal and apical portion of the wing and there is one large anal fold, incorporating the fourth anal vein when it is present. Of the former the first one is found in the discal part of the wing and extends from the base of the wing to near the radio-medial cross-vein. There may also be secondary folds given off from the vertices of this folded area. From the apical angle of this discal fold, the second fold, or the first primary, is given off and extends to the margin of the wing and extends between the portions of the radial sector. This is the key to the apical folds. From the posterior angle of the first primary fold arises the second primary, which extends to the margin of the wing incorporating the vein M_1 and M_2. This is a large and important fold, often giving rise to smaller folds which also extend to the margin of the wing. In the drawings showing the folds, the blackened areas represent those portions that are folded under when the wings are at rest and folded. The areas represented by striations represent crumples and other ill-defined folds. The convex sides of the folds have their edges fringed in the drawings.

The large fold of the posterio-basal portion of the wing is normally the largest of all and incorporates the fourth anal vein.

In the case of the leaf-mining genera, Brachys, Taphrocerus and Pachycelus, the longitudinal folding of the other genera is replaced by a more complicated semi-transverse folding. This is brought about by a division of the first primary fold and by the presence of several secondary folds and crumples. Even so they are recognizable as belonging to the Buprestid type.

2. The Stability of the Venation.

Is the wing-venation stable enough to be of any systematic value or must we utterly disregard this character? The reason for ignoring the venation has been that it was considered too variable and that no real conclusions could be derived from its study. All of the genera, with the exception of Chalcophorella, show a very distinct type of venation and a good combination of characters upon which they can be separated. Of the number of wings studied, individual variations were found in only two cases. These were in specimens of *Chrysobothris dentipes* Germ. and *Dicerca divaricata* Say. In the former, the variation is in the cell 2d-2dA. Instead of the branches ($2dA_3$ and $3dA_1$) forming the cell as is characteristic of the genus, the branches were separated. This was not so important because the small characteristic radial cell was present to identify the wing. As the cell 2d-2dA in this genus has normally a very short spur or lacks it entirely, this variation served as a stepping stone between the genera having an open and closed cell.

In the latter case, however, the variation is more serious as the variation is in the position of the radio-medial cross-vein (r-m). It is of importance because it involves a character which ordinarily distinguishes Dicerca Esch. from Psiloptera Sol. A large number of individual variations may be found in the anal region of the wings in the form of spurs either rising from the veins or are free. As they are of no taxonomic importance, their presence is of no importance.

The outstanding departure from the family type of venation is found in the genera of the tribe *Schizopini* (Schizopus, Dystaxia, Glyptoscelimorpha) and in the genus Mastogenius (Figs. 42, 43, 48, 49). In the former group, all have the same general type of venation, a type that is distinctly that of the family Dascyllidæ, as shown by the venation of the wing of

Dascyllus davidsonii Lec. (Fig. 41), characterized by media extending basad, the radial cell being situated more apically, and the radio-medial cross-vein much longer than is characteristic of the Buprestidæ. In the anal region there are seven distinct branches, the first six of which are connected, and the first two branches of the second anal vein are not separated as in the Buprestidæ. The genus Mastogenius differs in having but one unattached vein in the apical region of the wing, the beginning of the medial recurrent extends basad of the beginning of the radial sector, and, between the third and fourth anal veins there is a deep cleft which is not found in any of the more typical Buprestidæ. It is very difficult to say just where these forms do belong, as their life-histories are as yet unknown. They possess, however, all of the generally recognized characters of the family.

3. Phylogeny.

(a) Veins.

In order to understand the phylogeny as based on the wing-venation, it is necessary to study the different veins in their development and departures, and also to determine which characters are primitive, by comparing them with more generalized forms and closely related families. The Buprestidæ afford an excellent opportunity for the study of the phylogeny of venation, as many characters can be traced through their development and they are constant within a genus.

Subcosta normally unites with radius approximately opposite the radial cross-vein. From this primitive form, the modifications are brought about in either of two methods: (1) by fusing with costa and migrating basally or (2) by fusing with radius and also migrating basally, until a condition is reached as shown by the forms that have the radial cell lost. Here, the point of union is near the base of the wing, with the radial vein greatly thickened. This condition is also more or less realized in many of the higher families of the Coleoptera (Nitidulidæ, Ostomidæ, et al.).

In the radial vein, the specialization centers around the radial cell and the radial sector. For this, then, the two radial cross-veins must also be taken into consideration, and so they will be discussed in relation with this vein. In the primitive stage, the radial cell is large and elongate, as found in the genus

Buprestis and many other genera, but the more specialized forms have the size diminished until a stage is reached where it is lost (Agrilus). In the Adaphaga, the radial cell is very distinct and fairly wide while in the Serricornia, the Elateridæ, Lampyridæ and Dascyllidæ have a very large radial cell with an elongate radial cross-vein. The cross-veins, when present, may present two types of modification, the one in which the two cross-veins are more or less parallel as in the leaf-mining genera and in Polycesta (Fig. 27) and the other, the more common form in which the second radial cross-vein serves as an extension of the radial sector, in connecting the latter with the first branch of the radial vein.

The medial vein shows variation to the extent of the relative length of the fused portion of the vein to the length of the medial recurrent. In the primitive Hydrophilidæ, the Lampyridæ, and Elateridæ, the fused portion is very much shorter than the medial recurrent. The two extremes among the Buprestidæ are shown in Trachykele (Fig. 11) where the fusion is short and in Chrysobothris and Chalcophora (Fig. 15), where the fused portion extends well into the wing. The primitive condition and the modifications of cubitus are involved in and exactly correlate with what has just been said about media.

In the anal system of venation, the tendency is for the veins to atrophy. In the more primitive type, seven veins are present while in the more specialized forms the number is reduced to five (Brachys, Engyaulus). The first anal vein has its basal connection lost and is fused with the first branch of the second anal vein for a short distance before separating. It is continuous in the primitive and disrupted in the more specialized forms (Fig. 3, 6), or it may be absent, as in the leaf-mining genera. Vein $2dA_1$ is always present and so remains without any modifications. Vein $2dA_2$ becomes vestigial (Chrysophana, Fig. 31) and finally absent as in Engyaulus (Fig. 39). In the genus Agrilus, the $2dA_2$ vein is in most cases detached from the first branch of the vein and is free.

The cell 2d-2dA formed by the coalescence of the veins $2dA_3$ and $3dA_1$ apically, is a primitive condition among the Coleoptera. Although coalescence has been considered as a more specialized state of development, it is the reverse in the case of these two branches in the Coleoptera. In Cupes, all the Adaphaga, the majority of the Serricornia and some of the Heteromera, the

two branches unite and in the higher forms, as in the Lamellacornia and the Rhyncophora, the branches are separate. The more primitive forms have the spur of this cell quite long or as long as the cell itself, and the highest type of development obtains in the leaf-mining genera in which the veins are widely divergent.

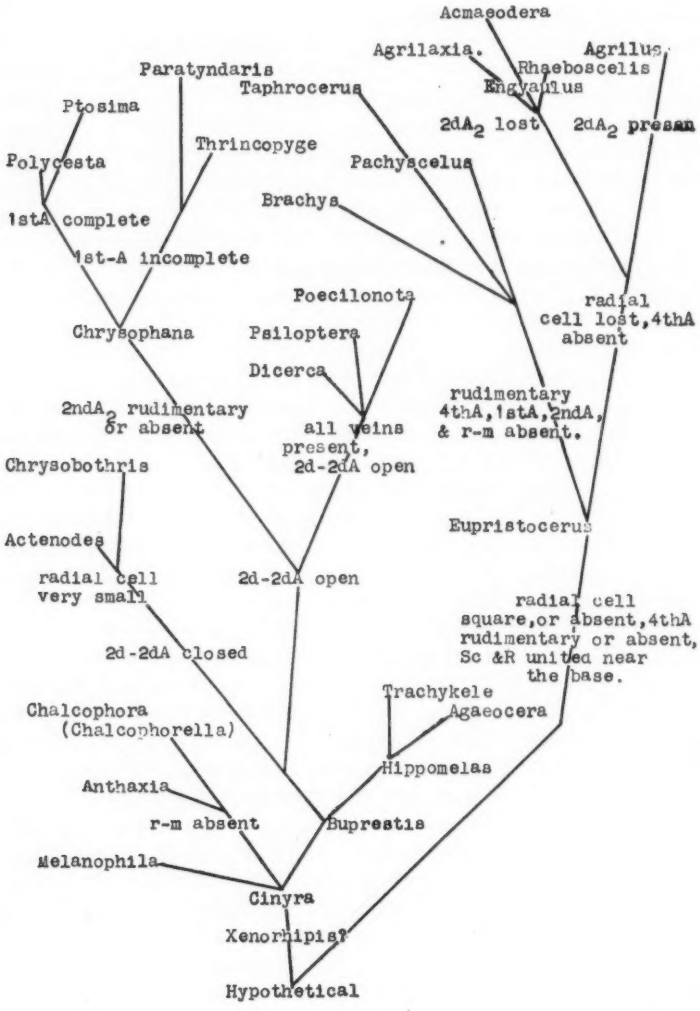
The vein 3dA shows little modification except for the relationship it holds with the vein $2dA_3$. In Brachys lævicaudus Lec. (Fig. 35), the vein $3dA_1$ is unattached to the second branch, while in Agrilus, $3dA_1$ fuses with $2dA_3$ at the base of the wing. The fourth anal vein has a tendency to become atrophied, being vestigial in the leaf-mining genera and absent in those genera that lack the radial cell.

(b) Cross-veins.

The cross-veins show a great amount of variation. As the radial cross-veins have already been discussed, they will be omitted here. The radio-medial cross-vein (r-m) is especially evident in its relative position to the first radial cross-vein. This cross-vein tends to migrate basad and finally to disappear. While in the Adaphaga and some of the Serricornia there are several radio-medial cross-veins, in the Buprestidæ there is but one and in some of the higher forms, even this is lacking. In the Lampyridæ and the Elateridæ, more primitive than the Buprestidæ, the radio-medial cross-vein is elongate and distad of the radial cross-vein. As the loss of veins indicated specialization and as there are as many as three in the Adaphaga, the more specialized type obtains in the Buprestidæ, where there is never more than one. Also, the beginning of the radial sector and the medial recurrent are quite close together, especially when the radio-medial cross-vein is absent.

The cubito-anal cross-vein (cu-a) likewise shows specialization by becoming atrophied. It may be complete, connecting the cubital and first anal vein, incomplete where it is attached to the anal vein but not to cubitus, or it may be absent. This latter condition prevails among the genera lacking the first anal vein or lacking the radial cell.

Perhaps the relationship of the genera can best be shown by constructing a genealogical tree. Since the accompanying tree does not take into consideration exotic genera, it can only be looked upon as tentative. There are two distinct types of vena-



Geneological Tree for the Buprestidae of North America.

tion found in the Buprestidæ. The one has both the radial cell and the fourth anal vein present and distinct and therefore is more primitive than the other type that lacks the radial cell, or if present, the fourth anal vein is vestigial.

In the more generalized of the two groups, one will observe that there is a further division into several types which are more or less closely related and in which the specialization can be followed.

At the base of the trunk is the hypothetical type of the family, in which all the characters are simple. Of the North American genera studied, Cinyra is the most primitive, having but three slightly specialized characters. These are, the fairly short radial cross-vein, the incomplete first anal vein, and the incomplete cu-a. Xenorhipis (Fig. 50) is very closely related to Cinyra, but as the wing was partially destroyed by fungous, and the drawing therefore reconstructed, its generic position should not be considered accurate. It appears to be more primitive in having the cu-a complete. From a type similar to Cinyra arise three branches. The first branch contains Melanophila which differs from Cinyra in lacking the radial cross-vein, and in this respect, differs from the other genera of the family. It is also specialized in having subcosta unite with costa midway between the base of the wing and the beginning of the radial cell. The second branch contains those genera that lack the radio-medial cross-vein, but in other respects are quite similar to the preceding genera. Of the genera comprising this group (Chalcophora and Anthaxia), the latter is the more primitive in having a longer spur to the 2d-2dA cell, the radial sector and the medial recurrent are more widely separated, the medial spur is as long as the fused portion of the medial vein, and the subcostal vein unites with radius. The third branch gives rise to forms still containing all the veins. The genera comprising this group are Buprestis, Hippomelas, Trachykele and Agæocera. The first three have a primitive type of radial cell, r-m is present and the main primitive characters are: cu-a complete in Agæocera and Trachykele, the fused median vein is complete, but subcosta unites with costa. Agæocera has but four specialized characters and so fits in with this group except for the partially open cell 2d-2dA, and the smaller radial cell.

From the Buprestis stem arises a forked branch, the one having the radial cell spherical and small and the cell2d-2dA

closed. The two genera comprising this group (Chrysobothris and Actenodes) are easily recognizable by the small radial cell and may be separated by the latter having a longer spur to the cell 2d-2dA. Chrysobothris has a very small spur or it may be absent.

The other fork includes the genera having the branches $2dA_3$ and $3dA_1$ divergent, the radial cell present and the fourth anal vein strong. In this group, one branch has all the veins present, containing the genera Dicerca, Psiloptera and Pœcilinota. They are all closely related to each other and can only be separated on the position of the radio-medial cross-vein, being distad, opposite and basad respectively of the radial cross-vein. The genus Psiloptera, however, had the cu-a vestigial in the species used.

So far, only those genera that have all the longitudinal veins present have been discussed. As there is reduction in the veins of many of the genera it will be necessary to refer to them next. This group comprises those genera that either have the vein $2dA_2$ rudimentary or absent. Chrysophana is the most primitive of this group, having a very large radial cell and the first anal vein is complete. Also subcosta unites with radius near the beginning of the radial cell. From a form having this type of venation arise two smaller groups. In one (including the genera Polycesta and Ptosima) the first anal vein is incomplete and has the radio-medial cross-vein connecting the beginning of the radial sector and the medial recurrent at their bases. Polycesta is the more primitive in having the vein $2dA_2$ vestigial and the cu-a complete, while the other group contains Paratyndaris (Fig. 29) and Thrincopyge (Fig. 32), differing from Polycesta and Ptosima in having the first anal vein incomplete, the radio-medial cross-vein distad from the bases of the radial sector and the medial recurrent, and the veins $2dA_3$ and $3dA_1$ less widely divergent. Thrincopyge is the more primitive of the two having a rudimentary $2dA_2$ present, the cu-a complete and in having the subcosta unite with costa.

The other main division of the family includes the more highly specialized genera. This division includes those forms that have the radial cell rectangular or absent and subcosta uniting in most cases with radius near the base of the wing. When the radial cell is distinct, the fourth anal vein is rudimentary, and when the cell is absent, the fourth anal vein is also

absent. The genus Eupristocerus differs from this general type in that it still preserves the radial cell, but in a very rudimentary state, as it is hardly visible. Otherwise in appearance, it more closely resembles the genera found in this higher group which lack the radial cell. It is quite similar to the Brachys group in the apical region in respect to the complex folding. However, the subcostal-radial union is more like that of the Agrilus group, as is also the case in the anal area exclusive of the fourth anal vein. The whole group can be characterized by a divergent 2d-2dA cell, by having the fused portion longer than the medial recurrent, and in lacking the cu-a.

The one group (Brachys, Taphrocerus and Pachyscelus) are characterized by having a square radial cell, r-m absent, 1stA, $2dA_2$, and cu-a absent, and the fourth anal vein rudimentary. Taphrocerus can easily be separated from the other two genera (Brachys and Pachyscelus) by the open radial cell and subcosta + radius remaining distinct from costa, while Pachyscelus has the radial cell more open. The other group retains the radio-medial cross-vein but lacks the radial cell. The first anal vein is incomplete and the $2dA_2$ when present (as in the genus Agrilus) may or may not be complete. The genus Agrilus, the most primitive of this group, can easily be recognized and separated from the other genera by the presence of the $2dA_2$ vein. Engyaulus (Fig. 39) is separated from Rhæboscelus (Fig. 46) by having a longer r-m, and the veins $2dA_3$ and $3dA_1$ are more divergent. Agrilaxia has a longer solid radio-medial cross-vein and the veins $2dA_3$ and $3dA_1$ are more narrowly divergent. Acmæodera (Fig. 47) has subcosta fused with radius more apically, the base of the radial sector and the medial recurrent connected by the radio-medial cross-vein, and $2dA_3$ and $3dA_1$ connected at the base of the wing. Acmæodera shows the highest degree of specialization. In general, considering the shape of the wing, the vestigial radial cell, the method of folding, and the presence of the fourth anal vein, the genus Eupristocerus appears to be more closely related to the Brachys group than to the Agrilus group.

The genera of the tribe Schizopini (Schizopus, Dystaxia and Glyptoscelimorpha) and the genus Mastogenius are not considered, according to wing-venation, in the phylogenetic relationship of the Buprestidæ as they have a venation not characteristic of the Buprestidæ. The genera of the Schizopini have a venation

similar to that of the Dascyllidæ, and it is possible that, as the Dascyllidæ are related to the Buprestidæ, they may have taken their origin from that family. Barber believes that Mastogenius is a Throscid. Its wing-venation is also somewhat similar (Forbes, Fig. 53) to that of the Throscidæ, although the venation in the anal region is quite like that of the Buprestidæ, except for the deep incision between 3dA and 4th A.

Another method to indicate the phylogeny to some extent, but better to show the degree of specialization of the genera is by means of a score-card, such as Tillyard, (Linn. Soc. N. S. Wales, v. 44) has used. In this method, the most primitive characters are assigned numerical values of one (1) while the more specialized forms are given correspondingly higher values.

(d). Key to the Numerical Values for the Degree of Specialization.

A.—Subcosta.
1. Fused with radius near the radial cross-vein.
2. " " " midway.
3. " " " basally.
3. " " costa midway between base of wing and the radial cross-vein.
2. " " costa near the radial cross-vein.

B.—Radius (radial cell).
1. Radial cell more or less quadrate.
2. " " " " " " (open).
3. " " large and elongate.
4. " " very small.
5. " " absent.

C.—Medial-cubital veins.
1. Fused veins shorter than the medial recurrent.
2. " " equal to the medial recurrent.
3. " " longer than the medial recurrent.
4. " " much longer than the medial recurrent.

D.—First anal vein.
1. Vein complete, united to $2dA_1$.
2. " not complete, not united to $2dA_1$.
3. " absent.

E.—Vein $2dA_2$.
1. Complete, united to $2dA_1$.
2. Not complete, not united to $2dA_1$.
3. Absent.

F.—Veins $2dA_2$ and $3dA_1$.
1. United distally, spur as long as cell.
2. " " " shorter than cell.
3. " " " vestigial.
4. Not united distally, not strongly divergent.
5. " " " very " "

G.—Third anal veins.
1. Veins united.
2. " separated.

H.—Fourth anal vein.
1. Prexsent, prominent.
2. Present, vestigial.
2. Absent.

I.—Radio-medial cross-vein.
1. Distad of first radial cross-vein.
2. Opposite " " "
3. Basad of " " "
4. Joining bases of Rs and medial recurrent.
5. Absent.

J.—Cubito-anal cross-vein.
1. Complete, connecting cubitus and 1st A.
2. Not complete, attached only to cubitus.
3. Absent.

From the above key, all that is necessary is to substitute the numbers for the degree of specialization under their proper headings. The most primitive or hypothetical form would have an aggregate sum of ten (the number of characters used) while the sums increase as the venation becomes more specialized.

(e). Score-card for Determining the Degree of Specialization.

Genus	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	Total Sum
Cinyra	1	2	1	2	1	1	1	1	1	2	13
Buprestis	2	2	2	2	1	1	1	1	2	2	16
Hippomelas	1	2	3	1	1	1	1	1	2	1	14
Trachykele	1	2	1	1	1	1	1	1	3	2	14
Melanophila	3	3	2	2	1	1	1	1	1	2	17
Anthaxia	1	2	2	2	1	1	1	1	5	1	17
Chalcophora	3	2	4	2	1	1	1	1	5	1	21
Actenodes	2	4	4	2	1	1	1	1	3	1	20
Chrysobothris	3	4	4	2	1	3	1	1	3	1	23
Agaeocera	3	2	3	2	1	4	1	1	2	1	20
Dicerca	3	2	2	1	1	5	1	1	1	1	18
Psiloptera	3	2	2	1	1	5	1	1	2	2	20
Poecilinota	3	2	2	1	1	5	2	1	3	1	21
Polycesta	3	1	3	1	2	5	1	1	4	1	22
Thrinocopyge	2	2	3	2	2	4	1	1	3	1	21
Ptosima	1	2	3	2	3	4	1	1	3	2	22
Paratyndaris	1	2	3	1	3	4	1	1	4	2	22
Eupristocerus	2	1	2	2	1	5	1	1	1	2	18
Brachys	2	1	3	3	3	5	2	2	5	2	30
Pachyscelus	2	2	3	3	3	5	2	2	5	2	31
Taphrocerus	2	2	3	3	3	5	2	2	5	2	31
Agrilus	2	5	3	2	2	5	1	3	3	3	29
Engyaulus	2	5	3	2	3	5	1	3	4	3	31
Rhaeboscelus	2	5	3	2	3	5	1	3	4	3	31
Agrilaxia	2	5	3	2	3	4	1	3	4	3	30
Acmaeodera	2	5	3	2	3	4	2	3	4	3	31

From the explanation of the development of the characters and the graphic representation shown on the score-card, it is quite evident why the genus Cinyra should be considered as the most primitive of the Buprestidæ. It has the least number of specialized characters while on the other hand, the genus Acmæodera should be considered as the most specialized, as it

is one of the genera having every character specialized to some extent. The remaining genera then are found scattered between these two extremes in having variable degrees of specialization.

The next interesting fact to consider is the relationship between the genera and tribes according to wing-venation and the system based on the generally recognized characters. For the latter, Kerremans' system will be used. To show this more distinctly, a linear arrangement of the genera will be given.

COMPARISON OF THE ORDER OF THE GENERA IN LINEAR ARRANGEMENT ACCORDING TO WING-VENATION AND TO KERREMANS.

Wing-venation	Kerremans
Xenorhipis	Chrysophana
Cinyra	Polycesta
Melanophila	Acmaeodera
Buprestis	Ptosima
Hippomelas	Paratyndaris
Trachykele	
Agaeocera	Thrincopyge
Anthaxia	Agaeocera
Chalcophora	Hippomelas
	Chalcophora
Actenodes	Psiloptera
Chrysobothris	
	Trachykele
Dicerca	Dicerca
Psiloptera	Poecilinota
Poecilinota	Cinyra
	Buprestis
Chrysophana	Xenorhipis
Ptosima	Melanophila
Polycesta	Anthaxia
Thrincopyge	Agrilaxia
Paratyndaris	
	Chrysobothris
Eupristocerus	Actenodes
Brachys	
Pachyscelus	Eupristocerus
Taphrocerus	Engyaulus
	Agrilus
Agrilus	Rhaeboscelus
Engyaulus	Pachyscelus
Rhaeboscelus	Brachys
Agrilaxia	Taphrocerus
Acmaeodera	

When the two systems, showing the relationship of the tribes and genera, are compared, it will be noticed that, tribe for tribe, there is considerable variation. This must be mainly due to the interpretation of characters. For instance, according to the wing-venation, the tribe containing the genus Buprestis is found to be the most primitive, while Kerremans puts it in

the middle of the family. Just the reverse is found to be the case in the tribe Polycestini. That is, Kerremans considers it the most primitive but according to the venation, the tribe is quite highly specialized. It is, however, the generic relations within a tribe that is of more importance. The first or most primitive genera are those that have all the veins present and quite similar. Two genera (Agæocera and Hippomelas) are added to Kerremans' Buprestini, as they are primitive enough to be placed with this tribe. On the other hand, Dicerca, Anthaxia and Agrilaxia, are taken out of the tribe. Anthaxia lacks the radio-medial cross-vein and as this is an important character, it seems justifiable to do so. Dicerca has the cell 2d-2dA open with the branches divergent and, as the Buprestini possess genera having the cell 2d-2dA closed, this genus has been taken out. The genus Agrilaxia shows the greatest divergence from this tribe. As it lacks the radial cell, cu-a, $2dA_2$, the cell 2d-2dA open and the fourth anal vein also absent, it hardly seems possible that it could show any close relation with the genera of the Buprestini. It has, therefore, been put in the Agrilini, with which it is closely related.

In the Chalcophorini are found the genera Anthaxia and Chalcophora. Both are characterized by the loss of the radio-medial cross-vein, but possesses all the other veins. Kerremens includes the genera Agæocera, Hippomelas, Chalcophora, Chalcophorella, and Psiloptera. The first two and the last possess the radio-medial cross-vein and so are eliminated on that ground. Chalcophorella has the same venation as Chalcophora and so can be considered synonymous as far as wing-venation is concerned. And Psiloptera also has the cell 2d-2dA open.

In the Chrysobothrini, both systems agree in possessing the two genera, Chrysobothris and Actenodes. Kerremens, however, considers the Chrysobothrini much more specialized than is represented by the wing-venation.

The Psilopterini include all the genera with 2d-2dA cell open but with all the longitudinal veins preserved. These are Dicerca, Psiloptera and Pœcilinota. There is no tribe, according to Kerremens, similar to this one, but the venation is so similar that they fall into this natural group. The other genera which he includes in this tribe have been put in other tribes already characterized.

The Polycestini differ from the tribe of Kerremens in that the genus Acmæodera has been taken out and put with the Agrilini as Acmæodera has the radial cell and the fourth anal vein absent, and the genus Thrincopyge has been added as it has the vestigial vein $2dA_2$, as is characteristic of the Chrysophana-Polyceta group.

In the Agrilini, Agrilaxia and Acmæodera have been added for reasons already explained. Otherwise, the tribe remains intact. The essential difference is the addition of the two genera and the grouping of Eupristocerus with the Brachys rather than with the Agrilus group.

KEY TO THE GENERA OF THE BUPRESTIDAE BASED ON THE WING-VENATION.

A. Cell 2d-2dA closed.
  B. Radio-medial cross-vein present.
    C. Subcosta uniting with costa midway between the base of the wing and the radial cross-vein.
      D. Radial cell elongate ..... *Melanophila*
      DD. Radial cell very small, round.
        E. Spur of cell 2d-2dA long ..... *Actenodes*
        EE. Spur of cell 2d-2dA vestigial or absent ..... *Chrysobothris*
    CC. Subcosta not uniting with costa in such a way.
      D. Radio-medial cross-vein opposite or basad of radial cross-vein.
        E. Subcosta uniting with costa ..... *Buprestis*
        EE. Subcosta uniting with radius.
          F. Medial recurrent longer than the fused portion of media.. *Hippomelas*
          FF. Medial recurrent much longer than fused portion of media. *Trachykele*
      DD. Radio-medial cross-vein distinctly beyond the radial cross-vein. *Cinyra*
  BB. Radio-medial cross-vein absent.
    C. Spur of cell 2d-2dA as long as the cell ..... *Anthaxia*
    CC. Spur of cell 2d-2dA short, medial recurrent much shorter than fused part. *Chalcophora* (*Chalcophorella*)
AA. Cell 2d-2dA open.
  B. Cell 2d-2dA slightly open.
    C. Radial cell conspicuous ..... *Agœocera*
    CC. Radial cell small, round ..... *Chrysobothris*
  BB. Cell 2d-2dA fully open.
    C. Radial cell present.
      D. R-m present.
        E. R-m distad of r ..... *Dicerca*
        EE. R-m opposite or bassd of r.
          F. R-m opposite r ..... *Psiloptera*
          FF. R-m before r.
            G. $2dA_2$ complete ..... *Poecilinota*
            GG. $2dA_2$ incomplete, either vestigial or absent.
              H. $2dA_2$ vestigial.
                I. Cu-a incomplete ..... *Chrysophana*
                II. Cu-a complete.
                  J. Radial cell triangular or quadrate ..... *Polycesta*
                  JJ. Radial cell long and narrow ..... *Thrincopyge*
              HH. $2dA_2$ absent.
                I. 1stA complete ..... *Ptosima*
                II. 1stA not complete ..... *Paratyndaris*

DD. R-m absent.
E. Radial cell complete.....*Brachys*
EE. Radial cell open.
F. Subcosta radius not uniting with costa.....*Taphrocerus*
FF. Subcosta and radius uniting with costa.....*Pachyscelus*
CC. Radial cell absent.
D. Subcosta uniting basally with radius.
E. Radial cell barely visible, vestigial.....*Eupristocerus*
EE. Radial cell distinctly absent, 4thA absent.
F. $2dA_2$ present.....*Agrilus*
FF. $2dA_2$ absent.
G. R-m not distinct; Rs and Mr not broadly connected at their base.
H. Cell 2d-2dA widely open.....*Engyaulus*
HH. Cell 2d-2dA not widely open.....*Rhaeboscelus*
GG. R-m distinct; base of Rs and Mr broadly connected..*Agrilaxia*
DD. Subcosta unites distally with radius.....*Acmaeodera*

SUMMARY.

In summarizing the foregoing results, the following conclusions have been reached.

1. That a knowledge of tracheation is essential in determining the homologies of the veins of the Coleoptera.

2. That the family possesses a definite venational type.

3. That the several genera each possesses a definite type of venation.

4. That the venation is sufficiently stable for profitable use in taxonomy.

5. That the folding arises subsequently to the venation and is therefore more or less independent of it.

6. That the three genera comprising the tribe Schizopini, Schizopus, Dystaxia and Glyptoscelimorpha, and the genus Mastogenius have a venation different from that of the Buprestidæ.

7. That the genus Agrilaxia and the genus Acmæodera show a decidedly different relationship, according to venation, than given by Kerremens. He represents Acmæodera as being very primitive but the venation is of the highest type. Agrilaxia was placed in the Melanophila-Buprestis group, but the venation places this genus also among the most specialized of the Buprestidæ.

8. That although coalescence is normally considered as a specialized condition, the reverse is true about the separating of veins $2dA_3$-$3dA_1$. They are fused apically in the primitive forms and become widely divergent in the more highly specialized.

EXPLANATION OF PLATES.

PLATE VIII.

Fig. 1. Pupal pad of Chrysobothris femorata (Oliv.).
Fig. 2. Wing showing Venation and Tracheation.
Fig. 3. Cinyra gracilipes Melsh.
Fig. 4. Buprestis fasciata Fab.
Fig. 5. Buprestis fasciata Fab. showing folds.
Fig. 6. Actenodes acornis (Say).
Fig. 7. Melanophila gentilis Lec.
Fig. 8. Melanophila gentilis Lec. showing folds.
Fig. 9. Hippomelas obliteratus (Lec.).
Fig. 10. Hippomelas obliteratus (Lec.) showing folds.
Fig. 11. Trachykele opulenta Fall. Courtesy of Dr. E. C. Van Dyke.
Fig. 12. Actenodes acornis (Say) showing folds.

PLATE IX.

Fig. 13. Chrysobothris dentipes (Germ.).
Fig. 14. Agaeocera gentilis (Horn). Courtesy of Mr. C. W. Leng.
Fig. 15. Chalcophora virginiensis (Drury).
Fig. 16. Chalcophora virginiensis showing folds.
Fig. 17. Chalcophora fulleri Horn. Courtesy of Mr. W. T. Davis.
Fig. 18. Chalcophorella campestris (Say).
Fig. 19. Chrysobothris dentipes (Germ.). showing folds.
Fig. 20. Anthaxia æneogaster Cast.
Fig. 21. Anthaxia æneogaster Cast. showing folds.
Fig. 22. Dicerca divaricata Say.
Fig. 23. Dicerca divaricata Say. showing folds.
Fig. 24. Psiloptera drummondi Castl.

PLATE X.

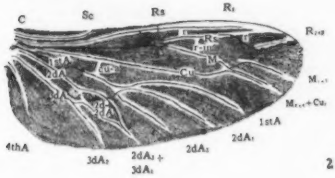
Fig. 25. Poecilonota cyanipes (Say).
Fig. 26. Poecilonota cyanipes (Say) showing folds.
Fig. 27. Polycesta californica Lec.
Fig. 28. Polycesta californica Lec. showing folds.
Fig. 29. Paratyndaris chamæleonis Skinner. Courtesy of Dr. H. S. Barber, Natl. Museum.
Fig. 30. Pachyscelus purpureus (Say).
Fig. 31. Chrysophana placida (Lec.).
Fig. 32. Thrincopyge alacris Lec.
Fig. 33. Thrincopyge alacris Lec. showing folds.
Fig. 34. Ptosima gibbicollis (Say).
Fig. 35. Brachys tessellatus (Fab.).
Fig. 36. Brachys tessellatus (Fab.) showing folds.

PLATE XI.

Fig. 37. Taphrocerus gracilis (Say).
Fig. 38. Eupristocerus cogitans (Web.).
Fig. 39. Engyaulus pulchellus (Bland). Courtesy of Dr. A. J. Mutchler, Amer. Museum.
Fig. 40. Agrilaxia flavimana (Gory). Courtesy of Dr. H. S. Barber.
Fig. 41. Dascyllus davidsonii Lec.
Fig. 42. Dystaxia murrayi Lec. Courtsey of Mr. C. F. A. Schaeffer.
Fig. 43. Glyptoscelimorpha marmorata Horn. Courtsey of Dr. H. S. Barber.
Fig. 44. Taphrocerus gracilis (Say) showing folds.
Fig. 45. Agrilus nevadensis Horn.
Fig. 46. Rhæboscelis tenuis Lec. Courtesy of Dr. H. S. Barber.
Fig. 47. Acmæodera vandykei Fall.
Fig. 48. Schizopus sallei Horn. Courtesy of Mr. C. W. Leng.
Fig. 49. Mastogenius subcyaneus Lec. Courtesy of Mr. C. F. A. Schaeffer.
Fig. 50. Xenorhipis brendeli Lec. (reconstructed). Courtesy of Mr. C. W. Leng.

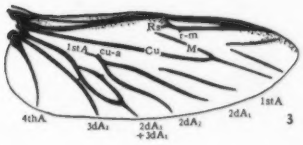
1

7



2

8



3

9

4

10

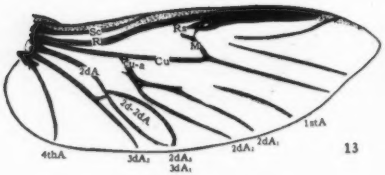
5

11

6

12

Henry G. Good

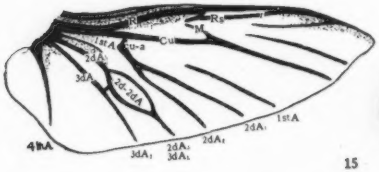


13

19

14

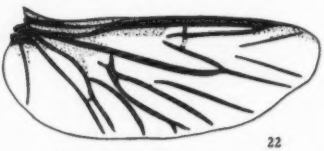
20



15

21

16

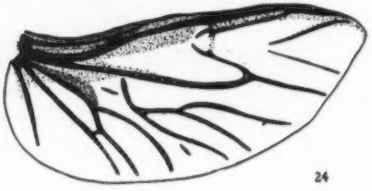


22

17

23

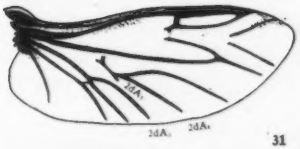
18



24

Henry G. Good

25



31

26

32

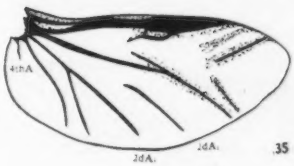
27

33

28

34

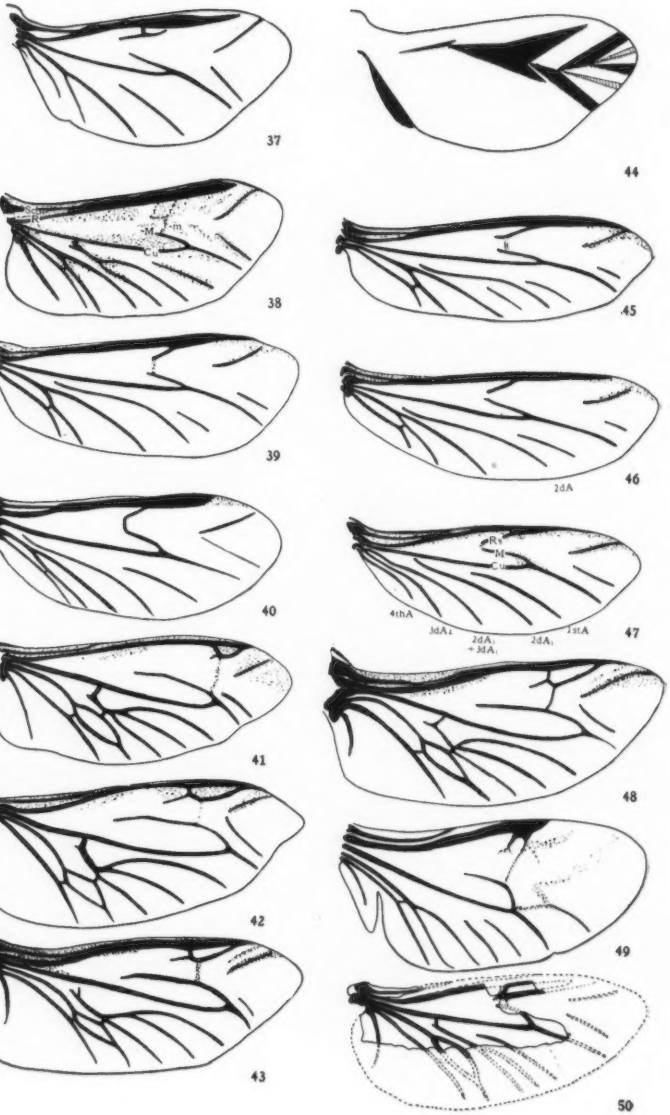
29



35

36

Henry G. Good


37
38
39
40
41
42
43
44
45
46
2dA
47
4thA
3dA1
2dA2 + MA1
2dA1
1stA
48
49
50

Henry G. Good

NOTES ON THE NORTH AMERICAN SPECIES OF THE GENUS DIDEA WITH THE DESCRIPTION OF A NEW SPECIES.

By FRANK M. HULL
Ohio State University.

The discovery of an interesting new species of the genus *Didea* from Northwest, as well as of another European species from North America, has led the writer to make a more extended study of the group. All three of the European forms have been included as it is not improbable that the third may also be found in this country. The genus, which was foundcd by Macquart, with *fasciata* as type, and contained only two species from North America at the time of Williston, now with the additions of the present paper, contains six species from this country. One other is listed from Europe and one or two have been described from the Orient.

Williston himself considered the genus as weakly characterized, a fact that becomes still more apparent when more species are studied. Practically all gradations exist in the curvature of the third vein. The beginning is found in *Syrphus arcuatus*, and is most extensive in *D. coquilletti*. One species of *Syrphus*, *annulipes* Zett., was once described as a *Didea* by Macquart. From a study of European material, the writer believes that it ought to be listed under *Didea*, and for purposes of comparison it has been included in the key. Certainly the third vein is here no less deeply bent than in several of the Northwestern *Didea*, which like *annulipes*, form a group with crossbands reaching side margins of the abdomen. *D. coquilletti*, however, stands quite between these and the more typical species, such as *fasciatus* and *alnetti*, possessing the character just mentioned, but having the third vein very deeply bent into the first posterior cell. The shape of the third antennal joint, or the second character used to distinguish the genus, is even less stable. In fact, the species may be divided into two groups, the one with shorter, more rounded antennæ, the others more pointed and elongate. A careful examination of *D. annulipes* (*Syrphus*), shows very little difference between it and the western *D. laxa* O. S. In the latter, however, the abdominal bands are slightly wider, and more deeply incised.

TABLE OF SPECIES OF *Didea*.

1. Cross bands of abdomen do not reach side margins.....2
   Cross bands attain side margins more or less widely or narrowly.....6
2. Bands of abdomen more or less widely interrupted medianly; incisions complete; antennal joint short oval, not pointed.....*daphne* n. sp.
   Bands of abdomen not completely interrupted; incisions incomplete; antennal joint elongate oval, more pointed.....3
3. Abdominal bands rather broad, yellow in color; third vein rather deeply bent..4
   Bands more greenish or bluish; rather narrow; third vein less deeply bent. *alnetti* Fall.
4. Black stripe of face reaching one-half or two-thirds distance to antennæ; venter yellowish.....5
   Black stripe limited to a small spot above epistoma, obsolescent; venter dull whitish.....*intermedia* Lw.
5. Cheeks and scutellum black.....*pacifica* Lov.
   Cheeks yellow or light brown; scutellum yellowish brown.....*fasciata* Macq.
6. Third vein deeply bent into first posterior cell, bands of abdomen with little or no incision.....*coquilletti* Will.
   Third vein quite shallowly bent; bands sometimes deeply incised.....6
7. Abdominal bands with very slight incisions; band of second segment usually narrower at the median extremity, than at the margin.....*annulipes* Zett.
   Abdominal bands deeply incised. Band of second segment usually more broad at median end.....8
8. Cheeks black; hind tibiæ with a wide black or brown band, largely brownish. *laxa var. syrphoides* var. n.
   Cheeks yellow to light brown; hind tibiæ usually with only a slender brown annulus, sometimes more extensive.....*laxa* O. S.

Didea laxa O. S.

About twenty specimens have been examined, from the following localities, Victoria, Mt. Cheam, Hope Mts., British Columbia, Mason Co., Washington. Thanks are due to Dr. R. C. Osburn for permission to study his material of the species, as well as of *Didea coquilletti*. Rather larger than other members of the genus. Figs. 5, 7.

Didea laxa var. **syrphoides** var. n.

Several specimens differ markedly from the typical *D. laxa* and are described as variety *syrphoides*. They differ chiefly in having the cheeks black or dark brown, and where the hind tibiæ of *laxa* have a rather narrow dark brown annulus near the middle, it is here much wider and the whole hind legs much darker. The facial stripe seems to extend further towards the antennæ. Moreover, there is a slight difference in appearance, *laxa* being not so dark nor so flattened and compressed. The characters above described, especially of the legs, seem to be somewhat variable.

Three females and one male, Wallface Mt., New York. July. (Nicolay), and one male, Mackinac Co., Michigan. May. (Moore). D. laxa has been recorded from New Hampshire, Michigan, and Maine, by Williston, as well as the west; perhaps all these records concern the variety above described. Holo-

type, allotype and paratype female, in the collection of the author: paratype male in the Ohio State University collection.

Didea fasciata Macq.

Material from Delair, Lucaston, N. J.; A. and M. College, Miss., Columbus, Ohio. I have seen only two or three European specimens of the species, determined by Lundbeck and Bezzi. I do not believe the differences warrant considering *D. fuscipes*, as the American form was described, distinct, or even a well marked variety. There seems to be some variation in the black coloration of the legs, especially of the hinder pair. Figs. 3, 4 and 8.

Didea pacifica Lovett.

I have not seen the species. It is described as differing from *D. fasciata*, in black cheeks, darker legs, size, wholly hyaline wings, and black scutellum. The first four characters might easily be variational. It may possibly be *D. alnetti*.

Didea alnetti Fallen

This and the following species, together with *D. fasciata* form a group of very close species, the more typical members of the genus, and difficultly separated. *D. alnetti* will be distinguished from *fasciata* by the characters given in the key. It is rather easily separated when the abdominal bands and venter, are, as is usually the case, of a pronounced bluish green coloration. The writer is indebted to Prof. J. S. Hine, who identified the species from Alaska (Nak-nek Lake; July, J. S. Hine), for permission to publish the record. *D. intermedia* is the only remaining European form not yet taken in this country. The loop of the third vein in *intermedia* and *fasciata* is deeper than in *alneti*, but in this the North American specimens of *fasciata* do not seem to entirely agree.

In the female sex, the fifth abdominal segment of *alneti* is always entirely black; those of the other two species possess small yellow spots. In all the specimens I have seen, *alneti* has the fourth abdominal band interrupted medianly, and the others never quite broken. Probably this would not hold for all specimens. The bands of *fasciata* are decidedly wider than in the others; particularly is this true of the second segment. *D. intermedia*, which is most obscurely distinguished, has a rather characteristic, whitish colored venter; *fasciata* and *alneti* have this region more yellowish or greenish.

Didea intermedia Loew.

I do not believe that the species can be easily confused, once one has become familiarized with the differences. European material has been very kindly furnished by Dr. Lundbeck. Fig. 9, abdomen of male.

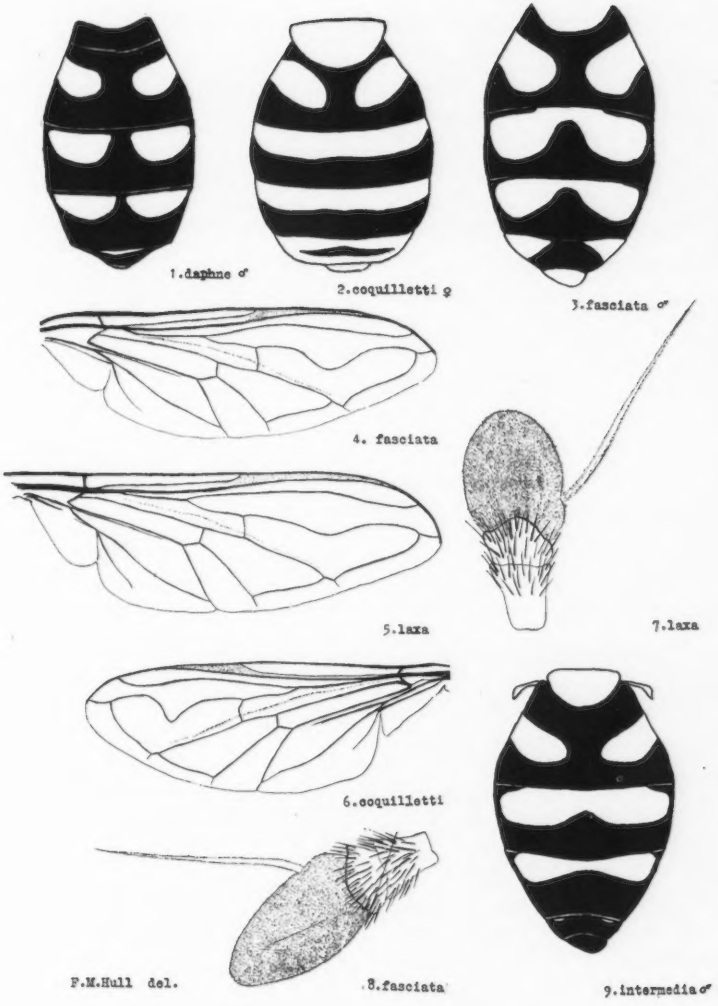
Didea coquilletti Williston.

Two specimens, male and female, labelled "Mexico," have been loaned for study by Dr. R. C. Osburn. The species presents a number of unusual points of interest. The third vein is the more strongly bent of any of the species. The yellow abdominal bands likewise reach the side margins rather broadly. The specimens are much more orange or brownish yellow than is shown by the Fig. in Biol. Cent. Amer., Vol. III, Pl. I. The eyes, in the figure, are shown slightly separated, which seems probably a mistake. It is not mentioned in the description, nor is it the case in the specimens before me. Distinctive points of the species are: Cross bands of the abdomen rather narrow, entire; face wholly yellow, largely shining; antennæ reddish, third joint black above, short but somewhat pointed; scutellum light yellowish; thorax shining, with a strong greenish cast; legs orange yellow, coxæ brownish; hypopygium yellowish brown. Figs. 2 and 6.

Didea daphne new species.

Male. Antennæ black, rather short and rounded; arista black. Face shining, pale brownish white or yellow, a broad black band extending nearly to the antennæ. Cheeks brownish. Pile of face yellowish; of frontal triangle and vertex rather long and black; of posterior orbit yellow. Dorsum of thorax shining black, with a faint greenish to bronze cast. Pile light brownish yellow. Scutellum dark brownish black; pile black. Pleuræ, with the exception of yellow mesopleuræ, black. Pile yellowish. Yellow bands of abdomen rather narrow and distinctly separated by black, medianly; not reaching the lateral margins on segments three and four. Fourth and fifth segments with a faint, narrow, yellow, posterior border. Fifth segment otherwise shining black. Preceding segments of abdomen opaque black, with a narrow, shining, posterior band on second and third, and a wider, similar band, on fourth segment. Hypopygium shining black. Legs black; tips of femora, tibiæ, except a middle annulus, wider on the hind pair, yellowish brown. Wing veins brownish black; loop of third vein rather shallow. Fig. 1.

Length, 12 mm. One specimen, holotype male, from Mt. Apex, Keremeos, British Columbia, (C. Garrett), in the collection of the author. Apparently a very distinct form. I know of no species of *Syrphus* under which it may have been described.



Drawings of *Didea;* wings, abdomens and antennæ.
All drawings made with camera lucida.

Frank M. Hull

LIST OF MEMBERS

Entomological Society of America

MAY 1, 1925.

The date of election as Honorary Fellow, Fellow or Member is shown by the date preceding the name.

Ch. signifies a charter member, December 28, 1906.

In the list of Fellows, the date following the address shows the date of election as a Member.

In the list of Honorary Fellows, the date of election as a Member is followed by the date of election as a Fellow.

The last item following the Member's name and address indicates the taxonomic groups or other phases of entomology in which he is particularly interested. If these group names are written in italics, it indicates he is willing to make identifications in these groups. Arrangements for such identifications should ordinarily be made by correspondence before materials are sent.

* The asterisk indicates Life Members in the Society.

HONORARY FELLOWS.

1914. BETHUNE, CHARLES J. S., 16 Washington Ave., Toronto, Canada. (Ch. 1906).

1914. COMSTOCK, JOHN HENRY, Cornell University, Ithaca, N. Y. (Ch. 1906).

1907. CRESSON, EZRA TOWNSEND, Hedgleih, Swarthmore, Pa. (Ch. 1907).

1915. FORBES, STEPHEN ALFRED, State Natural History Survey, Urbana, Ill. (Ch. 1907).

1924. HOWARD LELAND O., U. S. Bureau of Entomology, Washington, D. C. (Ch. 1907).

1914. SCHWARZ, EUGENE AMANDUS, U. S. National Museum, Washington, D. C. (Ch. 1907).

FELLOWS.

*1907. ALDRICH, J. M., National Museum, Washington, D. C. (Ch.) Diptera.

1920. ALEXANDER, C. P., Fernald Hall, Mass. Agr. College, Amherst, Mass. (1910). Tipulidæ.

*1908. BALL, E. D., U. S. Dept. Agr., Washington, D. C. (Ch.) *Jassidæ, Cercopidæ, Membracidæ.*

1914. BANKS, NATHAN, Museum Comp. Zoology, Cambridge, Mass. (1908).

1913. BARNES, WM., 320 Millikin Bldg., Decatur, Illinois. (Ch.).

1908. BEUTENMULLER, WM., Elm St., Tenafly, New Jersey. (Ch.). *Cynipidæ and their Galls.*

1920. BEZZI, MARIO, Via Pio Quinto, 3, Torino, Italy. (1908).

1925. BLAISDELL, F. E., SR., 1520 Lake St., San Francisco, Cal. *Tenebrionidæ, Histeridæ, Melyridæ.*

1914. BRADLEY, J. CHESTER, Cornell University, Ithaca, N. Y. (Ch.).
1925. BRAUN, ANNETTE F., 2702 May St., Cincinnati, Ohio. (Ch.). *Microlepidoptera* (By arrangement).
1914. BRITTON, W. E., Agr. Expr. Sta., New Haven, Conn. (Ch.). *Aleyrodidæ*, Coccidæ.
1914. BRUES, C. T., Bussey Institution, Boston 30, Mass. (Ch.).
1907. BRUNER, LAWRENCE, 1638 Lincoln St., Berkeley, Cal. (Ch.).
1917. BURGESS, A. F., 964 Main St., Melrose Highlands, Mass. (Ch.). Carabidæ.
1917. CAESAR, LAWSON, Ont. Agr. Coll., Guelph, Ontario, Canada. (1912).
1907. CALVERT, PHILIP P., Zool. Lab., Univ. Pennsylvania, Philadelphia. (Ch.). *Odonata*. (By arrangement.)
1908. COCKERELL, T. D. A., 908 Tenth St., Boulder, Colo. (1907). Bees, Fossil Insects.
1925. COOLEY, R. A., State College, Bozeman, Mont. (1910). *Diaspinæ*.
*1917. CRAMPTON, GUY C., 86 Pleasant St., Amherst, Mass. (1911).
1925. CRESSON, EZRA T., JR., 11 Amherst Ave., Swarthmore, Pa., (Ch.) Ephydridæ, Micropezidæ.
1917. DAVIS, JOHN J., Purdue Univ., Lafayette, Ind. (Ch.).
*1917. DAVIS, WILLIAM T., 146 Stuyvesant Place, Staten Island, N. Y. (Ch.). Cicadas.
1917. DEAN, GEO. A., Kansas State Agr. Coll., Manhattan, Kansas. (1913).
1925. DOANE, R. W., Stanford Univ., Cal. (Ch.).
1907. EMERTON, J. H., 30 Ipswich St., Boston, Mass. (Ch.). Spiders.
1907. FALL, H. C., Tyngsboro, Mass. (Ch.). *Coleoptera*.
1908. FELT, E. P., Nassau, Rens. Co., New York. (Ch.). Itonididæ.
1914. FERNALD, H. T., Mass. Agr. Coll., Amherst, Mass. (Ch.). *Sphecidæ*.
1907. FOLSOM, J. W., Tallulah, La., Delta Laboratory. (Ch.). *Collembola, Thysanura*.
1920. FUNKHOUSER, W. D., Univ. Kentucky, Lexington, Ky. (1911). *Membracidæ*.
1917. GIBSON, ARTHUR, Dominion Entomologist, Ottawa, Canada. (Ch.).
1907. GILLETTE, C. P., Fort Collins, Colo. (Ch.). Aphididæ.
1925. GOSSARD, H. A., Agr. Exp. Sta., Wooster, Ohio. (Ch.). Orthoptera, Hemiptera.
1920. HEADLEE, THOMAS J., New Brunswick, N. J. (Ch.).
1907. HENSHAW, SAMUEL, 28 Fayerweather St., Cambridge, Mass. (Ch.).
1914. HERRICK, GLENN W., 219 Kelvin Place, Ithaca, N. Y. (Ch.). Thysanoptera and Coccidæ.
1925. HINDS, W. E., State University, Baton Rouge, La. (Ch.).
1914. HINE, JAS. S., Ohio State Univ., Columbus, Ohio. (Ch.). Tabanidæ, Asilidæ.
1907. HOLLAND, W. J., Carnegie Museum, Pittsburgh, Pa. (Ch.).
1907. HOPKINS, A. D., 1708 Washington Ave., Parkersburgh, W. Va. (Ch.).
1921. HUNTER, S. J., Lawrence, Kansas. (Ch.).
1914. JOHANNSEN, O. A., College Agriculture, Ithaca, N. Y. (Ch.). Diptera.
1907. JOHNSON, CHAS. W., Boston Society Nat. Hist., 234 Berkeley St., Boston, Mass. (Ch.). Diptera.
1907. KELLOGG, VERNON, Nat. Research Council, 1701 Mass. Ave., Washington, D. C. (Ch.).

1920. KNAUS, W., McPherson, Kan. (Ch.). Coleoptera. *Cicindelidæ, Scarabæidæ, Cleridæ.*
1917. LENG, C. W., American Museum, New Brighton, Staten Island, New York City. (1912).
1917. LUTZ, FRANK E., Amer. Mus. Nat. Hist., New York City. (Ch.).
1920. MCDUNNOUGH, J., Entomological Branch, Ottawa, Canada. (1912). *Canadian Lepidoptera and Ephemeridoptera.*
1908. MARLATT, C. L., 1521 16th St., N. W., Washington, D. C. (Ch.). Coccidæ.
1917. MARSHALL, WM. S., 139 E. Gilman St., Madison, Wis. (Ch.) Anatomy and Embryology.
1914. MELANDER, A. L., State Coll., Pullman, Wash. (Ch.). Diptera.
1920. METCALF, C. L., Nat. Hist. Bldg., Univ. of Illinois, Urbana, Ill. (1912). Parasites of Domestic Animals, Syrphidæ.
1914. MORSE, ALBERT P., 16 Upland Road, Wellesley, Mass. (Ch.). Orthoptera.
1920. MOSHER, EDNA, Adelphi College, Brookyln, N. Y.
1917. MUIR, FREDERICK, H. S. P. A. Exp. Sta., Honolulu, Hawaii. (Ch.). *Fulgoridæ.*
1907. NEEDHAM, JAMES G., 6 Thurston Ave., Ithaca, N. Y. (Ch.). Odonata. *Ephemerida,* Plecoptera.
1925. O'KANE, WALTER C., Durham, N. H. (1908).
1907. OSBORN, HERBERT, Ohio State Univ., Columbus, Ohio. (Ch.). Homoptera, *Cicadellidæ.*
1917. OSBURN, RAYMOND C., Botany-Zoology Bldg., Ohio State Univ., Columbus, Ohio. (Ch.). Syrphidæ.
1914. PARROTT, P. J., Agric., Exp. Sta., Geneva, N. Y. (Ch.).
1914. PATCH, EDITH M., Exp. Sta., Orono, Me. (Ch.). Aphididæ.
1914. QUAINTANCE, A. L., Bur. Entom., Washington, D. C. (Ch.).
1914. REHN, JAMES A. G., Academy Nat. Sci., Logan Square, Philadelphia, Pa., (Ch.). Orthoptera, Dermaptera.
1914. RILEY, W. A., University Farm, St. Paul, Minn. (Ch.). Tabanidæ.
1920. SANDERS, J. G., Sun Oil Co., Finance Bldg., Philadelphia, Pa. (Ch.).
1920. SCHAUS, WILLIAM, U. S. Nat. Mus., Washington, D. C. (1919). Lepidoptera.
1920. SHELFORD, VICTOR E., Vivarium Bldg., Champaign, Ill. (Ch.). Ecology.
1920. SILVESTRI, FILIPPO R., Scuola Superiore d'Agricoltura, Portici, Italy. (1915). Thysanura, Protura, Termites, Myriopods.
1907. SKINNER, HENRY, Logan Sq., Philadelphia, Pa. (Ch.). Rhopalocera.
1914. SLOSSON, ANNIE T., 36 Gramercy Park, New York City. (Ch.).
1921. SWAINE, J. M., Dept. Agric., Ottawa, Canada. (1920). Forest Insects.
1912. VAN DUZEE, E. P., Cal. Acad. Sciences, G. G. Park, San Francisco, Cal. (Ch.). Hemiptera.
1917. VAN DYKE, EDWIN C., Univ. Cal., Berkeley, Cal. (Ch.). Elateridæ, Carabidæ, Buprestidæ.
1914. WALKER, E. M., Univ. Toronto, Toronto, Canada. (1910). *Canadian Odonata* and *Orthoptera.*
1925. WASHBURN, F. L., University Farm, St. Paul, Minn. (Ch.).
1925. WEED, CLARENCE M., State Normal School, Lowell, Mass. (Ch.).
1920. WELCH, P. S., Univ. Michigan, Ann Arbor, Mich., (1912). Aquatic Insects.
1907. WHEELER, W. M., Bussey Institution, Boston 30, Mass. (Ch.). Ants.
1914. WICKHAM, H. F., 911 E. Iowa Ave., Iowa City, Ia. (Ch.). Coleoptera.
1920. WILLIAMS, C. B., Ministry of Agric., Cairo, Egypt. Thysanoptera.
1914. WILLIAMSON, E. B., Bluffton, Ind. (Ch.). Odonata.

MEMBERS.

1908. AINSLIE, C. N., 5009 Orleans Ave., Sioux City, Iowa. Hymenoptera.
1907. AINSLIE, GEO. G., R. D. No. 9, Knoxville, Tenn. *Crambinæ, Aphididæ, Jassidæ, Thysanoptera.*
1913. ALLEE, W. C., Zoology Bldg., Univ. of Chicago, Chicago, Ill. Insect Behavior.
1923. ARMSTRONG, THOMAS, 411 B Saint Antoine St., Montreal, Quebec, Can.
1922. ARNOLD, GEORGE F., A. & M. College, Miss., Box 1. Cerambycidæ.
1918. BABCOCK, O. G. Box 407, Sonora, Texas. Mallophaga and Anoplura.
1922. BAERG, W. J., Fayetteville, Ark. Poisonous Arthropods.
1919. BAIRD, A. B., Entomological Branch, Dept. Agric., Ottawa, Ontario, Can. Ichneumonidæ.
1911. BAKER, A. C., East Falls Church, Va. *Aphiidæ* and *Aleyrodidæ.*
1912. BAKER, A. W., Ontario Agric. College, Guelph, Canada. *Mallophaga,* Coleoptera.
Ch. BAKER, C. F., Los Banos, Philippines. Jassoidea, Fulgoroidea, Ichneumonoidea.
1922. BAKER, HOWARD, 6915 Sixth St., Tacoma Park, D. C.
1919. BALDUF, W. V., 606 Michigan Ave., Urbana, Ill. Chrysomelidæ, Eurytomidæ.
1922. BANGHART, JOSEPH, 934 Hollister St., Olney, Ill. *Lepidoptera, Coleoptera.*
Ch. BANKS, CHARLES S., Bureau of Science, Manila, Philippines. Diptera, Hemiptera.
Ch. BARBER, H. G., 143 Third Ave. E., Roselle, N. J. *Hemiptera-Heteroptera.*
Ch. BARBER, H. S., U. S. National Museum, Washington, D. C. *Lampyridæ.*
1913. BARBER, L. S., Florida State College for Women, Tallahassee, Fla.
1923. BARE, CLARENCE O., 641 Missouri St., Lawrence, Kan.
Ch. BARLOW, JOHN, State College, Kingston, R. I.
1922. BARTLEY, HASTINGS N., 17 Division St., U. S. Entom. Lab., Silver Creek, N. Y.
1918. BASINGER, A. J., Citrus Exper. Station, Riverside, Cal.
1922. BATCHELDER, CHARLES H., 38 N. Main St., Orono, Maine.
1923. BATES, D. MARSTON, Ft. Lauderdale, Fla. Noctuidæ, Saturniidæ.
1922. BEAL, JAMES A., 496 Linwood St., Abington, Mass.
1924. BEAMER, RAYMOND H., 1000 Missouri St., Lawrence, Kan. *Cicadidæ.*
1920. BEDFORD, HUGH W., Khartoum, Sudan, Africa.
1924. BEEBE, WILLIAM, 33 W. 67th St., New York City.
1915. BENJAMIN, FOSTER, 500 W. Main St., Decatur, Ill. Lepidoptera.
1914. BENSEL, G. E., Spreckles, Cal.
Ch. BENTLEY, G. M., 406 Morrill Hall, Univ. Tennessee, Knoxville, Tenn.
1923. BENTON, CURTIS, Macomb, Ill.
*1917. BEQUAERT, JOSEPH C., Harvard Medical School, Boston, Mass. Hymenoptera, Diptera.
1909. BERGER, E. W., 223 W. 9th St. S., Gainesville, Fla.
1913. BETHUNE-BAKER, G. T., 20 Newbold Terrace, Leamington Spa., England.
Ch. BETTEN, CORNELIUS, 3 The Circle, Ithaca, N. Y. *Trichoptera.*
1913. BILSING, S. W., College Station, Texas. Cerambycidæ, Acrididæ.
Ch. BIRD, HENRY, 600 Milton Road, Rye, N. Y. Noctuidæ-Papaipema.

Ch. BISHOPP, F. C., Box 208, Dallas, Texas, U. S. Bur. of Entomology, *Siphonaptera, Anopleura, Ixodoidea.*
1924. BISHOP, SHERMAN C., N. Y. State Museum, Albany, N. Y. *Spiders, Phalangids.*
1913. BLACKMAN, M. W., N. Y. S. Coll. Forestry, Syracuse, N. Y. *Ipidæ, Cerambycidæ,* Buprestidæ.
1918. BLACKMORE, E. H., Box 85, Victoria, B. C. Lepidoptera of British Columbia.
1916. BLISS, CHESTER I., Dept. Zoology, Columbia Univ., New York. *Erythroneura* on grape.
1924. BLUM, SAMUEL, Drawer 330, Columbia, S. C.
1923. BOTTIMER, L. J. 702 Carter Bldg., Houston, Texas. Coleoptera.
1914. BOVING, ADAM G., U. S. Nat. Mus., Washington, D. C., *Coleopterous larvæ.*
1924. BOWE, MARTIN, 27 Gladstone St., Providence, R. I. Coleoptera.
1923. BOWEN, W. W., Wellcome Tropical Laboratories, Khartoum, Sudan, Africa.
1917. BOWERS, H. L., 31 N. Eastfield Ave., Trenton, N. J.
1922. BOYD, F. W., Box 1094, Billings, Mont. Orthoptera.
1919. BRADLEY, GEORGE H., Mound, La. Diptera.
1922. BRANCH, HAZEL E., 3756 East Douglas Ave., Wichita, Kan. Chironomidæ, Membracidæ.
1923. BRETHES, DR. JUAN, Mar Chiquita, 5033, General Urquiza (F. C. C. A.) Buenos Aires, Rep. Argentina.
1921. BRINLEY, FLOYD J., Japanese Beetle Lab., Riverton, N. J. Ecology.
1914. BROLEMANN, HENRY W., Box 22, Pau, Basses-Pyrenees, France.
1919. BROMLEY, STANLEY W., Fernald Hall, Amherst, Mass. Asilidæ, Tabanidæ, Odonata.
1925. BRONSON, BERNARD S., State College for Teachers, Albany, N. Y. Odonata.
Ch. BROOKS, FRED E., French Creek, W. Va. Fruit and Nut Insects.
1919. BRYAN, EDWIN H., Bishop Museum, Honolulu, Hawaii. Hawaiian Diptera.
1923. BRYSON, HARRY R., K. S. A. C., Manhattan, Kan.
Ch. Bueno, J. R. de la Torre, 11 North Broadway, White Plains, N. Y. *Aquatic Hemiptera.*
1922. BULGER, JACOB W., 423 Dorset Ave. and Chevy Chase Sts., Washington, D. C. Hymenoptera.
1912. BURRILL, A. C., State Board Agr., Jefferson City, Mo. Ants.
1919. BUYS, JOHN L., St. Lawrence Univ., Canton, N. Y. Homoptera. *Cicadellidæ.*
1924. BYERS, C. FRANCIS, 1313 Geddeys Ave., Ann Arbor, Mich. *Odonata,* Cicadidæ.
1922. BYNUM, ELI K., Box 331, Gulfport, Miss.
1917. CALDER, EDWIN E., Longmeadow, R. I.
1924. CAMACHO, CARLOS, Casilla 1248, Santiago, Chile.
1913. CAMPBELL, ROY E., Box 297, Alhambra, Cal. Syrphidæ.
*1914. CAPP, S. B., Box 2054, Philadelphia, Pa.
1915. CARNOCHAN, FREDERIC G., New City, Rockland Co., N. Y. Coleoptera.
1914. CARTER, HENRY F., Office of Malariologist, Colombo, Ceylon. Anopheles.
1922. CARTER, WALTER, Div. Ent. Univ. Farm, St. Paul, Minn. *Sphecoidea.*
1917. CARTWRIGHT, W. B., Box 283, Centralia, Ill.

1924. CASSINO, S. E., 20 Naples Road, Salem, Mass. Geometridæ.
1918. CAUDELL, A. N., U. S. Nat. Mus., Washington, D. C. Orthoptera.
1914. CHAFFEE, MRS. GERTRUDE B., Amenia, North Dakota.
1922. CHAMBERLAIN, JOSEPH C., Box 878, Stanford University, Cal. *Pseudoscorpionida*, Coccidæ, *Embiidæ*.
1924. CHAMBERLAIN, K. F., Cornwall Bridge, Conn. Cerambycidæ, Chrysomelidæ.
1917. CHAMBERS, E. L., Office of State Entomologist, Madison, Wis.
1914. CHAMPION, H. G., Imperial Forestry Inst., Oxford, England. Coleoptera.
1921. CHANDLER, S. C., Route 5, Carbondale, Ill.
1915. CHAPMAN, JAMES W., Silliman Institute, Dumaguete, Negros, P. I.
1925. CHAPMAN, PAUL J., Dept. Entomology, Ithaca, N. Y.
1914. CHAPMAN, Royal N., Dept. Animal Biology, University Minn., Minneapolis, Minn. Ecology.
1917. CHERMOCK, HUGO L., 1308 Tell St., North Side, Pittsburgh, Pa. *Lepidoptera*.
1913. CHILDS, LEROY, Hood River, Oregon.
1918. CLAASSEN, P. W., Cornell University, Ithaca, N. Y. *Plecoptera*.
1923. CLARK, S. W., Tic House, E. Lansing, Mich.
1914. CLAUSEN, CURTIS P., 2900 Negishi-maci, Yokohama, Japan. Chalcidoidea, Proctotrypoidea.
1917. COAD, B. R., Tallulah, La.
1916. COLE, FRANK R., Box 491, Orlando, Fla. Hymenoptera, Diptera.
1916. COLLINS, C. W., Gipsy Moth Lab., Melrose Highlands, Mass. *Calosoma*.
1921. COLMAN, WALLACE, Crawfordsville, Ind. Diptera.
1921. COMPTON, CHARLES C., Box 12, Aurora, Ill.
Ch. COOK, MEL T., Insular Experiment Station, Rio Piedras, P. R.
1919. COOK, WILLIAM C., Montana State College, Bozeman, Mont. Noctuidæ.
1921. COSTA-LIMA, ANGELO DA, Casa Luiz de Rezende-Rua do Ouvidor 116, Rio de Janeiro, Brazil. Nycteribiidæ.
1915. COTTON, RICHARD T., Bur. Ent., Washington, D. C. Larvæ of Curculionidæ.
1921. COWLES, RAYMOND B., Cornell University, Ithaca, N. Y. Coleoptera, Hymenoptera.
Ch. CRAWFORD, J. C., Dept. Agr., Raleigh, N. C. *Apoidea*.
1912. CREEL, CECIL W., Univ. of Nevada, Reno, Nevada.
Ch. CRIDDLE, NORMAN, Treesbank, Manitoba. Orthoptera, Coleoptera.
Ch. CROSBY, C. R., Roberts Hall, Ithaca, N. Y. *Araneæ, Opiliones*.
1914. CROSSMAN, S. S., 17 E. Highland Ave., Melrose Highlands, Mass. Parasitic Hymenoptera.
1915. CURRAN, C. H., Entomological Branch, Ottawa, Can. *Diptera*.
1921. CUTRIGHT, C. R., Ohio Agr. Exp. Sta., Wooster, Ohio. Aphiidæ.
1913. DAVIDSON, W. M. U. S. Insecticide Lab'y, Vienna, Va. Syrphidæ, Coccinellidæ, Aphiidæ.
1922. DAVIS, EDGAR W., Box 438, State Agr. Coll., Manhattan, Kan.
1925. DECHERD, GEORGE M., JR., 2809 Rio Grande St., Austin, Tex.
1924. DECKER, GEORGE C., Box 405, Albany, Ga.
1924. DE COURSEY, R. M., 1111 W. Univ. Ave., Urbana, Ill.

1917. De Garnett, R. T., 581 Merrimac St., Oakland, Cal. *Buprestidæ, Cicindelidæ.*
1914. De Gryse, Joseph J., Ento. Branch, Dept. Agr., Ottawa, Can.
1914. De Long, D. M., Dept. Zoology, Ohio State Univ., Columbus, Ohio. *Cicadellidæ*, Homoptera.
1919. Detwiler, John D., 844 Hellmuth Ave., London, Ontario, Canada.
1922. Dietrich, Henry, Appleton, N. Y. *Coleoptera.*
Ch. Dietz, Wm. G., 21 North Vine St., Hazelton, Pa.
1924. Dills, Leslie E., 145 Campus Ave., Ames, Iowa.
1922. Dodds, Clifford T., 429 N. 8th St., Santa Paula, Cal., Chalcididæ.
1922. Doering, Kathleen C., 1214 Tennessee St., Lawrence, Kans. Cercopidæ.
1922. Dohanian, S. M., 42 Cedar St., West Somerville, Mass. Parasitic Hymenoptera.
Ch. Doten, S. B., Experiment Station, Reno, Nevada.
1922. Doucette, Charles F., Greenhouse Insect Lab., Willow Grove, Pa. Greenhouse Insects.
1923. Douglass, J. R., Box 353, Estancia, N. M., Chrysomelidæ.
1922. Dowden, Philip B., 17 E. Highland Ave., Melrose Highlands, Mass. Parasitic Hymenoptera.
1917. Dowell, Philip, 86 Bond St., Port Richmond, Staten Island, N. Y.
1925. Downing, Elliot R., 6031 Kimbark Ave., Chicago, Ill.
1922. Drake, Carl J., Iowa State College, Ames, Iowa. Tingitidæ.
1925. Duffy, Leo F., 18 Longview St., Springfield, Mass.
1923. Duncan, Carl D., State Teachers College, San Jose, Cal. *Vespidæ, Bembicidæ.*
1919. Dunn, Marin S., Phila. Coll. of Pharmacy and Science, Philadelphia, Pa.
1924. Dunn, Melvin B., Entom. Branch, Ottawa, Canada.
1916. Du Porte, E. Melville, Macdonald College, Quebec. Diptera, Ixodoidea.
1917. Duran, Victor, 1554 S. Wilton Place, Los Angeles, Cal.
1914. Dusham, E. H., College Heights, State College, Pa. Coleoptera.
Ch. Easton, Norman S., 458 High St., Fall River, Mass. Coleoptera.
1923. Eddy, C. O., Clemson College, S. Car.
1913. Edmonston, W. D., Kanab, Kane Co., Utah. *Dendroctonus.*
Ch. Edwards, Edwin H., 1633 Westwood Ave., Lakewood, Ohio.
Ch. Ehrhorn, Edw. M,, Box 2520, Honolulu, Hawaii. Coccidæ.
1924. Elmore, John C., Box 297, Alhambra, Cal.
1917. Elrod, M. J., Missoula, Mont.
1911. Ely, Charles R., 6 Kendall Green, Washington, D. C. Gracilariidæ.
1919. Emerson, Alfred E., Dept. Zoology, Univ. Pittsburgh, Pittsburgh, Pa. *Termites.*
1922. Emery, George, 249 Lakeside Ave., Marlboro, Mass.
1914. Enburg, John M., 5207 Baltimore Ave., Philadelphia, Pa.
Ch. Engelhardt, George P., Museum, 373 Ocean Ave., Brooklyn, N. Y. *Aegeriidæ.*
1922. Esaki, Teiso, Ento. Lab., Coll. Agr., Kiushiu Imperial Univ., Fukuoka, Japan. Heteroptera.
1910. Essig, E. O., Room 201 A. H., Univ. Cal., Berkeley, Cal. *Aphididæ*, Coccidæ.
1914. Evenden, James C., Coeur d'Alene, Idaho. Forest Entomology.

Ch. EWERS, WILLIAM V., 44 North Goodman St., Rochester, N. Y. Diptera.
1910. EWING, H. E., U. S. Nat. Museum, Washington, D. C. Acarina, Protura, Mallophaga, Arachnida, Anoplura, Siphonaptera.
1918. EYER, JOHN R., Field Lab'y, North East, Pa. Microlepidoptera.
1917. FACKLER, HARRY L., State Entomologist's Office, Knoxville, Tenn.
1917. FATTIG, P. W., 207 Pine St., Farmville, Va.
1923. FAZ, ALFREDO, Calle Bandera No. 714, Santiago, Chile, South America.
1915. FENTON, F. A., Box 65, Florence, South Carolina. Hymenoptera.
1914. FERRIS, G. F., Stanford Univ., Cal. Coccidæ, Psyllidæ, Ectoparasites.
Ch. FIELD, W. L. W., Milton Academy, Vose's Lane, Milton, Mass. Lepidoptera.
1922. FILINGER, GEORGE A., Box 6, Kansas State Agr. Coll., Manhattan, Kan.
1910. FINK, D. E., Riverton, N. J. Insect Physiology.
1907. FISHER, W. S., U. S. Nat. Museum, Washington, D. C. *Buprestidæ, Cerambycidæ.*
1923. FLEBUT, A. JOHN, 201 Sansome St., San Francisco, Cal.
1922. FLEMING, ANDREW, Sibley, Adams Co., Miss.
1922. FLETCHER, FRANK C., 1900 3rd St., N. E., Minneapolis, Minn. Tenebrionidæ.
1919. FLETCHER, ROBERT K., College Station, Texas. Heteroptera.
1908. FLINT, W. P., Natural History Bldg., Urbana, Ill.
1919. FLORENCE, LAURA, Box 284, Princeton, N. J. Anoplura.
1923. FLUKE, CHARLES L., Dept. Economic Ent., Univ. of Wis., Madison, Wis. *Syrphidæ*, Bombyliidæ.
*1908. FORBES, WILLIAM T. M., 23 Trowbridge Road, Worcester, Mass. Lepidoptera *of Northeastern States.*
1922. FORD, NORMA, 96 Dunn Ave., Toronto, Ontario, Canada. Orthopteroid Insects.
1919. FOURNIER, MRS. GASTON, 90 Boulevard Malesherbes, Paris (8) France. Lepidoptera.
1912. FOX, HENRY, Japanese Beetle Lab'y, Riverton, N. J. *Orthoptera*, Scarabæidæ.
1911. FRACKER, S. B., State Capitol, Madison, Wis., Coreidæ.
1922. FRANCE, L. V., 1459 Hythe St., St. Paul, Minn. Apiculture.
1918. FRANK, ARTHUR, Box 217, Puyallup, Wash.
1923. FRANKENFIELD, C. L., Box 86, Keego Harbor, Mich. Chrysomelidæ.
1923. FREEBORN, STANLEY B., University Farm, Davis, Cal. Culicidæ.
1922. FRIEND, ROGER B., Agr. Exp. Sta., New Haven, Conn. Diptera.
1914. FRISON, T. H., Nat. Hist. Bldg., Urbana, Ill. *Bremidæ, Evaniidæ.*
1923. FRITZ, LULU G., 1183 Grand Ave., Topeka, Kan.
Ch. FROST, C. A., 67 Henry St., Framingham, Mass. Coleoptera.
1914. FROST, S. W., Arendtsville, Pa. *Phytomyza*, Agromyzidæ.
Ch. FULLAWAY, D. T., Board of Agriculture, Box 3319, Honolulu, Hawaii, Braconidæ.
1916. FULTON, B. B., Iowa State College, Ames, Iowa. Sta. A. *Orthoptera.*
1924. FURR, J. R., White Haven, Tenn.
Ch. GAHAN, A. B., U. S. National Museum, Washington, D. C. Chalcidoidea, Braconidæ.
1916. GAIGE, FREDERICK M., Museum of Zoology, Univ. Mich., Ann Arbor, Mich. *Formicidæ.*

1922. GARLICK, W. G., Vineland Station, Ontario.
1914. GARMAN, PHILIP, Conn. Agr. Exp. Sta., New Haven, Conn. *Odonata*, Acarina.
1922. GEHRING, JOHN GEORGE, Bethel, Maine. Coleoptera.
1916. GENTNER, LOUIS G., 213 Bailey St., East Lansing, Mich. *Halticinæ*.
Ch. GERHARD, WM. J., Field Mus. Nat. Hist., Chicago, Ill. Hemiptera.
1922. GERRY, BERTRAM, 20 Union Park, Boston, Mass.
1912. GIBSON, EDMUND H., 1317 G St., N. W., Washington, D. C.
1913. GIBSON, FRANK M., 235 W. Lafayette Ave., Baltimore, Md. Lepidoptera.
*Ch. GIFFARD, W. M., Box 308, Honolulu, Hawaii.
1922. GILMER, PAUL M., State College, New Mexico. Hymenoptera.
1924. GLADNEY, HORACE, A. & M. College, Miss.
1916. GLASER, RUDOLF W., Rockefeller Inst. for Medical Research, Princeton, N. J. Relation Microorganisms to Insects.
1911. GLASGOW, HUGH, Experiment Station, Geneva, N. Y.
1911. GLASGOW, ROBERT D., Nat. Hist. Bldg., Urbana, Ill. *Phyllophaga*.
1919. GLICK, PERRY A., 134 S. Second St., Philadelphia, Pa.
1921. GOOD, HENRY G., Zool. & Entom., Auburn, Alabama. Coleoptera.
1908. GOODWIN, W. H., High School, North Lima, Ohio.
Ch. GRAENICHER, SIGMUND, Box 14, Larkins, Fla. Aculeate Hymenoptera, Muscoid Diptera.
1924. GRAF, JOHN E., Bureau Entom., Washington, D. C.
1917. GRAHAM, SAMUEL A., Univ. Farm, St. Paul, Minn. Ipidæ, Cerambycidæ, Buprestidæ.
1922. GRANOVSKY, ALEXANDER A., 1532 University Ave., Madison, Wis. Aphididæ.
1914. GREENE, CHARLES T., Box 51, East Falls Church, Va.
1924. GREER, ALBERT H., 701 Polk Ave., Houston, Texas. Heterocera, Culicidæ.
1919. GRISWOLD, GRACE H., Dept. Entomology, Ithaca, N. Y.
1914. GUBERLET, JOHN E., Univ. Washington, Seattle, Wash.
1924. GUI, HARRY L., 318 Vattier St., Manhattan, Kansas.
1921. GUYTON, F. E., Auburn, Ala. Blattidæ.
1916. GUYTON, T. L., Bur. of Plant Ind., Dept. of Agr., Harrisburg, Pa. *Aphididæ*.
1923. HADLEY, CHARLES H., Bureau Plant Ind., Harrisburg, Pa.
1924. HAEUSSLER, GILBERT J., 94 Monmouth St., Springfield, Mass.
1914. HAGAN, HAROLD R., Univ. Utah, Salt Lake City, Utah. Diptera.
1922. HALL, MAURICE C., Zoological Div. Bur. An. Ind., Washington, D. C. Parasites of domestic animals.
1914. HALLINEN, J. E., Cooperton, Kiowa Co., Oklahoma.
1921. HALLOCK, HAROLD C., 19 E. Central Ave., Moorestown, N. J. Diptera, *Trypetidæ*.
1914. HAMILTON, CLYDE C., Rutgers College, New Brunswick, N. J. Larvæ of Cicindelidæ and Carabidæ.
1916. HAMLIN, JOHN C., Box 164, Fresno, Cal. Membracidæ, *Chelinidea*.
1923. HAMMOND, GEO. H., MacDonald College, Quebec, Canada. Noctuidæ.
1922. HAMNER, A. L., Box 1252, Auburn, Ala. Aphididæ.
Ch. HANSEN, JAMES, St. John's Univ., Collegeville, Minn.

1924. HARDENBERG, CHRISTIAN B., Box 255, Sourenco Marquis, Portuguese E. Africa.
1922. HARINGTON, R. J., 86 Pleasant St., Amherst, Mass.
1907. HARNED, R. W., Box 1, State Plant Board, Agricultural College, Miss.
1923. HARRIS, HALBERT M., Iowa State College, Ames, Iowa. Heteroptera, *Nabidæ*.
1924. HARRIS, REGINALD G., Biol. Laby., Cold Spring Harbor, L. I., N. Y.
1924. HART, CECIL, Box 432, R. 1, Montebello, Cal.
1922. HARTLEY, EDWIN A., N. Y. State Coll. of Forestry, Syracuse, N. Y. Parasitic Hymenoptera.
1920. HARTZELL, ALBERT, 1086 N. Broadway, Boyce-Thomson Inst., Yonkers, N. Y. Cicadellidæ.
1907. HARTZELL, F. Z., 321 W. Main St., Fredonia, N. Y. Coleoptera.
Ch. HASEMAN, LEONARD, Univ. of Missouri, Columbia, Mo. Psychodidæ.
1919. HATCH, MELVILLE H., Dept. of Zool., Univ. of Mich., Ann Arbor, Mich. Histeridæ, Silphidæ, Gyrinidæ.
1919. HAYES, WM. P., Natl. Hist. Bldg., Urbana, Ill. Immature Insects.
1923. HERBST, PAUL, Casilla 3528, Valparaiso, Chile. Hymenoptera.
1920. HERTIG, MARSHALL, Dept. Animal Biol., Univ. Minn., Minneapolis, Minn. Insect Symbionts.
1917. HERTZOG, P. H., Hightstown, N. J.
1916. HESS, WALTER N., De Pauw Univ., Greencastle, Ind. Lampyridæ.
1908. HEYWOOD, MRS. R. E., 826 Water St., Webster City, Iowa.
1919. HILL, CHARLES C., Kronenberg Bldg., Carlisle, Pa.
1908. HILTON, W. A., Claremont, Cal.
Ch. HODGKISS, H. E., Botany Bldg., State College, Pa. Eriophyidæ.
1917. HOFER, GEO., Box 1658, Tucson, Arizona. Forest Insects.
1914. HOFFMAN, WM. A., care of Sanitary Eng., 1st Brigade, U. S. Marine Corps, Port au Poine, Haiti. Ceratopogoninæ, Halticini.
1919. HOFFMAN, WM. E., Dept. Biology, Canton Christian College, Canton, China. *Aquatic Hemiptera*.
1919. HOKE, GLADYS, Como, Miss. Coccidæ.
1924. HOKE, SARA, Zoology Dept. State College, Ames, Iowa.
1913. HOLLOWAY, T. E., 8203 Oak St., New Orleans, La.
1912. HOOD, C. E. Melrose Highlands, Mass.
1913. HORTON, J. R., 126 S. Minneapolis Ave., Wichita, Kansas. Lachnosterna.
1923. HOTTES, FREDERICK C., Entom., Iowa State College, Ames, Iowa. Aphididæ.
1924. HOUGH, WALTER S., Winchester, Va. Coccidæ.
Ch. HOUSER, J. S., Ohio Agr. Exp. Sta., Wooster, Ohio. Coccidæ.
Ch. HOWARD, CHARLES T., 1735 East Ave., Rochester, N. Y. Lepidoptera.
*1907. HOWARD, CHAS. W., Christian College, Canton, China.
1914. HOWARD, NEALE F., Drawer E, Woodlawn P. O., Birmingham, Ala.
1917. HOWE, R. HEBER, JR., Belmont Hill School, Belmont, Mass. Odonata.
1914. HOWES, GEORGE, 432 George St., Dunedin, New Zealand, Ephemeridæ.
Ch. HUARD, V. A., 2 Richelieu St., Quebec, Canada. Lepidoptera.
1923. HUBBELL, T. H., Univ. Florida, Gainesville, Fla. *Orthoptera*.
1921. HUBER, L. L., Agr. Exp. Sta., Wooster, Ohio. Chalcidoidea.

1921. HUCKETT, HUGH C., Vegetable Research Farm, Riverhead, L. I., N. Y. Anthomyiidæ.
1922. HULL, FRANK M., Dept. Entom., Ohio State Univ., Columbus, Ohio. *Syrphidæ, Stratiomyidæ, Tabanidæ.*
1925. HUMPHRIES, J. D., University Tennessee, Knoxville, Tenn.
1909. HUNGATE, J. W., State Normal School. Cheney, Wash.
1916. HUNGERFORD, H. B., Museum Building, Lawrence, Kansas. *Corixidæ, Nepidæ, Notonectidæ, Hydrometridæ, Mesoveliidæ.*
Ch. HUNTER, W. D., Dept. Agr. Washington, D. C. Diptera.
1917. HUSSEY, ROLAND F., N. Y. University, Wash. Square, New York City. Hemiptera.
1908. HYSLOP, J. A., Bureau of Entomology, Washington, D. C. Elateridæ.
*1911. ILLINGWORTH, J. F., Bishop Museum, Honolulu, Hawaii. Muscoid Flies.
1924. INGERSOLL, EVERETT H., K. S. A. C., Manhattan, Kansas. Orthoptera.
1914. ISELY, DWIGHT, 2 N. Duncan St., Fayetteville, Ark. Eumenidæ.
1922. ISHIMORI, NAOTO, Coll. Agr. & Forestry. Morioka, Japan. Lepidopterous larvæ.
1907. JACKSON, C. F., Durham, N. H. Ecology.
1915. JACKSON, L. O., High School, Colorado Springs, Colorado. *Aphilanthops*, Fossorial Wasps.
1924. JANVRIN, E. R. P., 515 Park Ave., New York City. Coleoptera.
1920. JAQUES, H. E., Mt. Pleasant, Iowa. Phyllophaga.
1925. JEANNEL, R., Universitates din Cluj, Casuta Postala No. 158, Cluj, Roumania.
1910. JENNINGS, H. R., Lowell High School, Hayes & Masonic Ave., San Francisco, Cal. Diptera.
1915. JEWETT, H. H., Agr. Exp. Sta., Lexington, Ky.
1925. JOHNSON, KARL W., Entomology Dept., Ames, Iowa.
Ch. JOHNSON, S. ARTHUR, State Agr. College, Fort Collins, Colo.
Ch. JONES, FRANK M., 2000 Riverview Ave., Wilmington, Delaware. *Psychidæ.*
1916. KAHL, HUGO, Carnegie Mus., Pittsburgh, Pa. *Odonata*, Diptera.
1921. KEEN, SADIE E., Box 45, Forest Grove, Ore. Cereal and Forage Insects.
Ch. KELLER, GEORGE J., 68 Treacy Ave., Newark, N. J. Catocalæ.
1923. KELLY, E. G., K. S. A. C., Manhattan, Kansas.
1924. KELSHEIMER, EUGENE G., Zoology Dept., Iowa State College, Ames, Iowa. Tachinidæ.
1914. KENNEDY, CLARENCE H., Entom. Dept., Ohio State University, Columbus, Ohio. Odonata, Morphology.
1921. KESSEL, MRS. QUINTA CATTEL, 109½ Elston Pl., Ithaca, N. Y. Streblidæ.
Ch. KINCAID, TREVOR, Univ. Washington, Seattle, Wash. *Psychodidæ*, Tenthredinoidea.
1914. KING, H. H., Wellcome Tropical Research Lab., Khartoum, Anglo-Egyptian Sudan, Africa.
1912. KING, J. L., 3233 Carnegie Ave., Cleveland, Ohio. Diptera.
1923. KING, KENNETH M., Univ. Saskatchewan, Saskatoon, Sask., Canada. Noctuidæ.
1919. KING, ROBERT L., Zool. Lab., Univ. Pa., Philadelphia, Pa. Orthoptera.
1918. KINSEY, ALFRED C., Indiana University, Bloomington, Indiana. *Cynipidæ.*
1911. KNIGHT, HARRY H., State College, Ames, Iowa. Heteroptera, *Miridæ.*

1922. KNIGHT, PAUL, Dept. Entom. Univ. Illinois, Urbana, Illinois.
1924. KNOWLTON, GEO. F., Zoology Dept., Ohio State Univ., Columbus, Ohio. *Aphiidæ*, Hemiptera.
Ch. KOTINSKY, JACOB, 5154 Parkside Ave., Philadelphia, Pa. Chermes.
1917. KRAATZ, WALTER C., Municipal Univ., Akron, Ohio.
1923. KRAFKA, JOS., JR., Le Conte Hall, Univ. Georgia, Athens, Ga. Trichoptera Diptera.
1923. KUWAYAMA, SATORU, Hokkaido Agr. Exp. Sta., Sapporo, Japan. Neuroptera, Mecoptera, Trichoptera, Psyllidæ of Japan.
1914. LAAKE, E. W., Box 208, Dallas, Texas. Immature Muscidæ and Oestridæ.
1924. LACEY, JOHN S., 13 Elm St., Holyoke, Mass.
1919. LACROIX, DON S., Fernald Hall, Amherst, Mass.
Ch. LAGAI, GEORGE, 8533 110th St., Richmond Hill, L. I., N. Y. Lepidoptera.
1912. LAMKEY, ERNEST M. R., Agr. Exp. Sta,. Newark, Delaware.
Ch. LANG, JOSEPH N., 1433 S. 59th Ave., Cicero, Ill.
1917. LANGE, RICHARD C., 551 N. Clay Ave., Kirkwood, Mo. Coleoptera, Lepidoptera.
1917. LANGSTON, J. M., Box 1, A. & M. College, Miss. Phyllophaga.
1914. LARRIMER, W. H., Box 95, W. Lafayette, Ind. Cicadellidæ.
1913. LATHROP, FRANK H., Clemson College, S. C. Cicadellidæ.
1919. LATHY, PERCY I., 90 Bd. Malesherbes, Paris, France. Lepidoptera.
1924. LATTIMORE, ROBERT, 702 Carter Bldg., Houston, Texas.
1923. LAUDERDALE, JOE L. E., Box 368, Yuma, Ariz.
Ch. LAURENT, PHILIP, 31 E. Mt. Airy Ave., Philadelphia, Pa.
1917. LAWSON. PAUL B., 605 Maine St., Lawrence, Kansas. Homoptera. *Cicadellidæ*.
1922. LEARNED, ELMER T., 46 Franklin St., Fall River, Mass. Lepidoptera.
1912. LEIBY, R. W., State Dept. Agr., Raleigh, N. C. Insect Polyembryony.
1917. LINDSEY, A. W., Box 782, Granville, Ohio. *Hesperiidæ*.
1914. LITTLER, FRANK M., Box 114, Lanceston, Tasmania, Australia.
1924. LIU, CHUNG LO, Dept. Entom., Cornell Univ., Ithaca, N. Y. Vespidæ.
Ch. LLOYD, J. T., Court & Plum Sts., Cincinnati, Ohio.
Ch. LOCKHEAD, W., Macdonald College, Quebec, Canada.
1919. LOCKWOOD, STEWART, Box 1094, Billings, Mont. Orthoptera.
1922. LOUNSBURY, CHARLES P., Box 513, Pretoria, S. Africa.
1919. LOWRY, P. R., New Hampshire Coll., Durham, N. H. *Coccidæ, Mealy Bugs*.
1913. LUGINBILL, PHILIP, U. S. Entom. Sta., Columbia, S. C. Phyllophaga.
1917. LUNDBECK, WM., Zoological Museum, Copenhagen, Denmark. Diptera.
1923. LUTZ, ADOLPHUS, Cairea de Correio 926, Rio de Janeiro, Brazil.
1914. MCATEE, W. L., Biolo. Sur., U. S. Dept. Agric., Washington, D. C. *Emesidæ, Eupterygidæ*.
1920. MCBRIDE O. C., Box 491, Orlando, Fla. *Cerambycidæ*, Buprestidæ.
1907. MCCRACKEN, MISS ISABEL, Box 44, Stanford Univ., Cal. *Cynipidæ*, Apoidea.
1917. MCCULLOUGH, JAMES W., Agr. Exp. Sta., Manhattan, Kan. Scarabæidæ.
1910. MCDANIEL, EUGENIA, I., Agr. Coll., East Lansing, Mich.
1924. MACDOUGAL, ALICE PEARCE, Biology Dept., Univ. Toronto, Toronto, Ont. *Aphididæ*, Pentatomidæ, Coccinellidæ.
1923. MCEVILLY, J. E., State Plant Board, McComb, Miss.

1925. McGeoch, Charles R., Fernald Hall, Amherst, Mass.
1925. McGregor, Ernest A., Box 576, Lindsay, Cal. Tetranychidæ.
1911. McIndoo, N. E., Bur. Entom., Washington, D. C. Insect Physiology.
1919. McMahon, E. A., 27 Hickson Ave., St. Lambert, Quebec, Can.
1921. McNeill, Jerome, Thonotosassa, Fla. Orthoptera.
1923. Mabee, W. Bruce, Dept. Agr., Raleigh, N. C.
1917. Maheux, Georges, Parliament Bldg., Quebec, Canada. Buprestidæ, Cerambycidæ.
1922. Mank, Edith W., 12 Reservoir St., Lawrence, Mass. Coleoptera.
1921. Mank, Helen Gardner, 12 Reservoir St., Lawrence, Mass.
*1913. Mann, William M., U. S. Nat. Mus., Washington, D. C. Formicidæ, Ant Guests, Termitophiles.
1923. Manter, Jerauld A., Agr. College, Storrs, Conn.
1922. Marcovitch, Simon, Agr. Exp. Sta., Knoxville, Tenn.
1924. Marshall, M. C., 213–12 Hollis Ave., Bellaire, L. I., N. Y.
1921. Mason, Arthur C., Box 576, Lindsay, Cal. *Thysanoptera.*
1912. Mason, P. W., U. S. Bur. Entom., Washington, D. C. *Aphididæ.*
1916. Mason, Shirley L., P. O. Box 1817, Houston, Texas.
Ch. Matheson, Robert, Cornell Univ., Ithaca, N. Y. *Ixodoidea, Culicidæ.* Blood-sucking Arthropoda.
1923. Mathewson, A. A., 502 Sophia St., Maumee, Ohio.
1917. May, R. M., 2135 Sacramento St., San Francisco, Cal.
1923. Merrill, George B., State Plant Board, Gainesville, Fla. Coccidæ.
1909. Metcalf, Z. P., State College Sta., Raleigh, N. C. *Homoptera.*
1917. Mickel, Clarence E., Entomology, University Farm, St. Paul, Minn. *Mutillidæ.*
1922. Middleton, William, Bur. of Entom., Washington, D. C. Chalastogastrous larvæ.
1921. Miller, August E., Entom. Field Lab'y, Chillicothe, Ohio. *Acarina.*
Ch. Miller, Ellen Robertson, Coronado Beach, Florida. Lepidoptera.
1921. Mitchell, Theo. B., State Dept. Agr., Raleigh, N. C. Apoidea.
*1921. Moffatt, Elizabeth M., Wheaton, Ill. Araneida.
1922. Montgomery, B. Elwood, Poseyville, Ind. Coleoptera, Odonata.
1908. Moore, William, American Cyanimid Co., 511 Fifth Ave., N. Y.
1923. Moreira, Carlos, Rua Sta. Clara 26, Copacabana, Rio de Janeiro, Brazil.
1908. Morgan, Ann H., South Hadley, Mass. Ephemeridæ.
Ch. Morgan, H. A., Univ. of Tenn., Knoxville, Tenn.
Ch. Morrill, A. W., 382 North Ave., 53, Los Angeles, Cal. Aleyrodidæ.
1922. Morris, Walter Markley, 44 Triangle St., Amherst, Mass.
1912. Morrison, Harold, Bur. Entom., Washington, D. C. Coccidæ.
1914. Moseley, Martin E., 94 Campden Hill Road, London, W. Eng. Trichoptera.
1920. Mote, Don C., Agr. College, Corvallis, Ore.
1915. Muesebeck, C. F. W., 17 E. Highland Ave., Melrose Highlands, Mass. *Braconidæ,* Ichneumonidæ, Chalcidoidea.
1924. Munro, H. K., Box 16, East London, S. Africa. Syrphidæ, *Trypaneidæ.*
1917. Mutchler, Andrew J., Amer. Mus. Nat. Hist., New York City. *Lampyridæ, Cicindelidæ.*
1915. Muttkowski, R. A., Univ. of Idaho, Moscow, Idaho. Aquatic Insects.

1921. NAUDE, T. J., Botany-Zoology Bldg., Columbus, Ohio. Cicadellidæ.
1912. NEILLIE, CHAS. R., 4317 E. 116th St., Cleveland, Ohio.
1921. NEILSON, ERNEST, Care of Chris. E. Olsen, Amer. Mus. Nat. Hist., New York City.
1921. NEISWANDER, C. R., Oak Harbor, Ohio. Aquatic Hemiptera.
1907. NELSON, JAS. A., Route 3, Mt. Vernon, Ohio.
Ch. NESS, H., 821 Kellogg Ave., Ames, Iowa.
Ch. NEWCOMB, W. W., 1245 Ferdon Rd., Ann Arbor, Mich. Lycænidæ, Hesperidæ, Noctuidæ.
Ch. NEWCOMBER, E. J., Box 243, Yakima, Washington.
1907. NEWELL, WILMON, Agr. Exp. Sta., Gainesville, Fla.
1915. NEWMAN, GEORGE B., 142 S. Frazier St., State College, Pa.
1922. NOBLE, W. B., Box 95, W. LaFayette, Ind.
*1917. NOTMAN, HOWARD, 136 Joralemon St., Brooklyn, N. Y. *Carabidæ*, Staphylinidæ, *Stenus*.
1916. OLSEN, CHRIS E., Amer. Mus. of Nat. Hist., New York City.
1924. ORR, PAUL R., Zool. Lab., University Penna., Philadelphia, Pa.
1908. OSBORN, H. T., care of United Sugar Cos., Los Mochis, Sinaloa, Mex.
Ch. OSLAR, ERNEST J., 4535 Raleigh St., Denver, Colo.
1920. OTANES, FAUSTINO Q., Bureau of Agr., Manila, Philippine Islands.
1917. OUELLET, JOSEPH, 1145 St. Viateur Ave., Outremont, Quebec.
1915. PACKARD, CLYDE M., 600 Twenty-sixth St., Sacramento, Cal.
1913. PADDOCK, F. B., Sta. A, Ames, Iowa. Apiculture.
1918. PAINTER, H. R., U. S. Entom. Lab., Box 95, W. Lafayette, Ind. Orthoptera. *Acrididæ*.
1919. PAINTER, REGINALD H., Entomology Dept., Ohio State Univ., Columbus, Ohio. *Bombyliidæ*, *Asilidæ*, *Conopidæ*.
1923. PALLISTER, JOHN C., Mus. Nat. Hist., 2717 Euclid Ave., Cleveland, Ohio. *Coleoptera*.
1923. PARK, O. WALLACE, State College, Ames, Iowa. Apiculture.
1924. PARKER, DONALD L., 77 Chase Ave., North Adams, Mass.
1918. PARKER, J. B., 1217 Lawrence St., N. E. Washington, D. C. Bembicidæ.
1924. PARKER, RALPH L., Dept. Entomology, Ithaca, N. Y. Apiculture.
1916. PARKER, R. R., U. S. P. H. S., Hamilton, Mont. *Sarcophagidæ*, Acarina.
1916. PARKS, H. B., State Apiculture Lab., Box 638, San Antonio, Texas.
1918. PARKS, T. H., Ohio State Univ., Columbus, Ohio.
1924. PARMAN, D. C., Box 509, Uvalde, Texas. *Muscoid Diptera*, Anoplura, Mallophaga.
1912. PARSHLEY, H. M., Smith College, Northampton, Mass. *Heteroptera*.
Ch. PAXSON, OWEN S., Radnor, Delaware Co., Pa.
1923. PAYNE, NELLIE M., Univ. Farm, St. Paul, Minn. Trichoptera.
1919. PEAIRS, L. M., Morgantown, W. Va. Mallophaga, Thysanoptera.
1924. PELTIER, PAUL X, Box 68, Spencer, Mass.
1911. PETERSON, ALVAH, Bureau of Entomology, Riverton, N. J. Diptera.
1907. PETRUNKEVITCH, ALEXANDER, Osborn Zool. Lab., Yale Univ., New Haven, Conn. Arachnida.
Ch. PETTITT, R. H., Agr. Exper. Sta., East Lansing, Mich. Coccidæ.
1921. PHILLIPS, E. F., Cornell Univ., Ithaca, N. Y. Apiculture.

1912. PHILLIPS, W. J., U. S. Entom. Lab., Box 299, Charlottesville, Va. *Harmolita.*
Ch. PIERCE, W. DWIGHT, Box 57, Banning, Cal. Rhynchophora, Strepsiptera.
1924. PLATH, O. E., Bussey Inst., Boston 30, Mass. Bremidæ.
1913. POOS, FRED W., European Corn Borer Lab., Sandusky, Ohio. *Harmolita, Bombidæ.*
1918. POPE, THOMAS E. B., Public Museum, Milwaukee, Wis.
1923. PORTER, BENNETT A., 10 W. Sycamore, St., Vincennes, Ind.
1921. POTGIETER, JOHANNES T., School Agr., Glen, O. F. S., S. Africa.
Ch. POWELL, P. B., Clinton, N. Y.
1915. POWERS, EDWIN B., Univ. of Tenn., Dept. Zoology, Knoxville, Tenn.
1916. PRICE, W. A., Station F, Columbus, Ohio.
1916. PSOTA, FRANK J., 4046 W. 26th St., Chicago, Illinois. Cetonidæ.
Ch. RAMSDEN, CHAS. T., P. O. Box 146, Guantanamo, Cuba. *Sphingidæ, Diurnal Lepidoptera.*
1923. RANDOLPH, ABRAHAM M., Casilla 1, Valdivia, Chile, S. America.
1913. RAU, PHIL, 2819 S. Kingshighway Blvd., St. Louis, Mo. Aculeate Hymenoptera.
1923. READIO, PHILIP A., 1203 Oread Ave., Lawrence, Kan.. Terrestrial Heteroptera.
1923. REED, WILLIAM D., Ent. Zool., Clemson College, S. C. Diptera.
1922. REED, W. V., State Capitol, Atlanta, Ga. Insects of Ornamental Plantings.
1923. REEVES, Jos. A., B. & Z. Bldg., Ohio State Univ., Columbus, Ohio. Chrysomelidæ.
1908. REGAN, W. S., Montana State Coll., Bozeman, Mont. Psammocharidæ.
1917. REIS, JACOB A., Kribi, care of Presbyterian Mission, Cameroun, W. Africa.
1921. REMY, T. P., 4 Dooley Bldg., Houston, Texas.
1914. RICHARDSON, CHARLES H., Bureau of Entomology, Washington, D. C. Insect Physiology.
1922. RIES, DONALD T., 401 Thurston Ave., Ithaca, N. Y. Hymenoptera.
1914. RIS, F., Rheinan, Canton Zurich, Switzerland.
1922. ROBERTS, H. E., U. S. Entom. Lab., 551 N. Clay Ave., Kirkwood, Mo. Coleoptera.
1915. ROBINSON, J. M., Dept. Zool., Auburn, Ala. Coccidæ, Coleoptera.
1925. ROBINSON, THERESA M., 502 Dryden Rd., Ithaca, N. Y.
1913. ROCKWOOD, L. P., Forest Grove, Ore.
1922. RODRIGUEZ, MAURO G., State Coll., Bozeman, Mont. Tropical Insects.
1915. ROGERS, J. SPEED, Univ. Florida, Gainesville, Fla. Tipuloidea.
1923. ROGERS, LESLIE, Agr. Exper. Sta., New Haven, Conn. *Rhopalocera,* Coleoptera.
1922. ROOT, FRANCIS M., School Hyg. & Pub. Health, 310 W. Monument St., Baltimore, Md. Diptera, *Anopheles,* Muscidæ.
1914. ROSENFELD, ARTHUR H., Insular Exper. Sta., Rio Piedras, Porto Rico.
1924. ROSS, CHARLES F., 87 Summer St., Lee, Mass.
1912. ROSS, WILLIAM A., Dominion Entom. Lab., Vineland Sta., Ontario. *Aphididæ.*
1914. RUCKES, HERBERT, 1171 Sherman Ave., Bronx, New York City.
1923. RUFFIN, W. A., Box 247, Auburn, Ala.
Ch. RUGGLES, A. G., University Farm, St. Paul, Minn.

1919. RUHER, MAX M., Forest Grove, Ore. Cereal and Forage Insects.
Ch. RUMSEY, W. E., 415 Park St., Morgantown, W. Va.
1923. SALMAN, KENNETH A., care of Direccion General de Agricultura, San Salvador, El Salvador, C. A. Cerambycids.
1907. SANDERS, G. E., Entom. Lab., Annapolis Royal, N. S., Canada.
Ch. SASSCER, E. R., Fed. Hort. Board, U. S. Dept. Agr., Washington, D. C.
1907. SATTERTHWAIT, ALFRED F., U. S. Entom. Lab., 551 N. Clay Ave., Kirkwood, Mo. *Calendra.*
1924. SAZAMA, ROBERT F., 19 Arlington St., Northampton, Mass.
1919. SCHMEIDER, RUDOLPH G., 4351 Pechin St., Philadelphia, Pa.
Ch. SCHOENE, W. J., Agr. Exp. Sta., Blacksburg, Va.
1919. SCHWARZ, FRED, 4523 Tenn. Ave., St. Louis, Mo..
1925. SCOTT, WALTER A., Mt. Kisco, N. Y. Lepidoptera.
1923. SEAMANS, HOWARD L., Dominion Ent. Lab'y. Lethridge, Alberta. Anthomyiidæ, *Muscidæ.*
1924. SEELEY, RALPH M., 310 Elmwood Ave., Ithaca, N. Y. *Tetragnatha,* Diaspidinæ.
1922. SELLERS, WENDELL, 51 Clifford St., Melrose, Mass.
1908. SEVERIN, H. C., State Coll., Brookings, S. D. Orthoptera, Heteroptera.
1907. SHAFER, GEO. D., 321 Melville Ave., Palo Alto, Cal.
*1919. SHANNON, RAYMOND C., U. S. Nat. Mus., Washington, D. C. Diptera.
1922. SHEPARD, HAROLD H., 86 Pleasant St., Amherst, Mass. *Hesperiidæ.*
1917. SHERMAN, FRANKLIN, State Dept. Agr., Raleigh, N. C. Carabidæ, Cicindelidæ, Cerambycidæ.
1911. SHERMAN, JOHN D., JR., 132 Primrose Ave., Mt. Vernon, N. Y. Dytiscidæ.
1923. SHOTWELL, ROBERT L., Box 1094, Billings, Mont. Acrididæ, *Coccidæ.*
Ch. SHULL, A. FRANKLIN, 520 Linden St., Ann Arbor, Mich. Thysanoptera.
1919. SIBLEY, CHARLES K., Dept. Entom., Cornell Univ., Ithaca, N. Y.
1923. SILVER, JOSEPH C., 17 E. Highland Ave., Melrose Highlands, Mass.
Ch. SMITH, JAMES A., 401 Lenox Ave., Westfield, N. J.
1919. SMITH, MARION R., Dept. Entomology, Univ. Illinois, Urbana, Ill. *Ants.*
1918. SMITH, RALPH H., 425 Battery St., San Francisco, Cal.
1914. SMITH, ROGER C., Agr. Coll., Manhattan, Kan. Neuropteroids, *Chrysopidæ.*
1914. SMULYAN, MARCUS T., U. S. Bur. Entom., Melrose Highlands, Mass. Tenthredinidæ, *Tenthredella.*
Ch. SMYTH, ELLISON A., JR., Va. Poly. Inst., Blacksburg, Va. *Papilio, Sphingidæ.*
1918. SNAPP, OLIVER I., U. S. Bur. Entom., Fort Valley, Ga. Rhynchophora, Conotrachelus.
1924. SNODGRASS, R. E., 3706 Thirteenth St., N. W., Washington, D. C. Morphology.
1922. SNYDER, THOMAS E., U. S. Bur. Entom.. Washington, D. C. *Isoptera.*
*1914. SPENCER, G. J., Univ. of British Columbia, Vancouver, B. C. Trypetidæ.
1919. SPENCER, HERBERT, Va. Truck Exp. Sta., Box 881, Norfolk, Va. Parasitic Hymenoptera.
1921. SPENCER, ROBERT D., Ashland State Hospital, Ashland, Pa. Diptera.
1924. SPONG, PHILIP, State Normal School, Box 732, Wayne, Neb. Cicindelidæ, Chrysomelidæ.

Ch. SPOONER, CHARLES S., 1436 Seventh St., Charleston, Ill. Hemiptera.
1922. SPULER, ANTHONY, 611 Mich. Ave., Pullman, Wash. Diptera.
1910. STAFFORD, E. W., Agr. College, Miss. Acalyptrate Muscoids.
1919. STAHL, C. F., Compania Cuba, Ingenio Jobabo, Jobabo, Cuba.
1919. STEAR, J. R., 119 S. Main St., Chambersburg, Pa. Miridæ.
1917. STEARNS. LOUIS A., Box 155, Leesburg, Va. Cercopidæ, Cicadellidæ.
1923. STEELE, BRANDT F., 811 E. Drive, Woodruff Place, Indianapolis, Ind. Coleoptera.
1921. STEVENS, O. A., Agr. Coll., N. Dak. Bees and Wasps.
1925. STEWART, KENNETH E., 148 Brighton Ave., Ottawa, Can.
1923. STEWART, MORRIS A., Room 223, Bur. Biol. Survey, Washington, D. C.
1914. STICKNEY, FENNER S., Indio, Cal. Coleoptera.
1915. STILES, CHARLES F., Box 37, Stillwater, Okla.
1922. STIRRETT, GEO. M., Univ. of Minnesota, St. Paul, Minn. Halticini.
1913. STONER, DAYTON, 603 S. Summit St., Iowa City, Iowa. *Pentatomoidea.*
1912. STRICKLAND, E. H., The University, Edmonton, Alberta.
Ch. SUMMERS, H. E., 712 Edison St., Los Angeles, Cal.
1908. SUMMERS, JOHN N., 964 Main St., Melrose Highlands, Mass. Coccidæ.
1921. SWEET, GEORGINA, The University, Melbourne, Australia.
1923. SWEETMAN, HARVEY L., Iowa State College, Ames, Iowa.
1920. SWEZEY, OTTO H., H. S. P. A. Exp. Sta., Honolulu, Hawaii. Lepidoptera, Coleoptera.
1921. SWIFT, F. R., Box 3, Bocu del Toro, Republic of Panama. Diptera.
1922. SWINGLE, HOMER S., Sta. F., R. D. 3, Columbus, Ohio.
1921. TAKAHASHI, RYOICHI, Dept. Agr., Gov. Research Inst., Taihoku, Formosa, Japan. Aphididæ, Coccidæ.
1913. TALBERT, THOMAS JESSE, Whitten Hall, Columbia, Mo.
Ch. TANQUARY, M. C., Box 361, Fargo, N. D.
1922. TAYLOR, LELAND H., Dept. Zoology, W. Va. Univ., Morgantown, W. Va. *Chrysididæ.*
1922. TERANISHI, CHO., No. 12, Nagi, Shirokita-mura, Higashinari-gun, Osaka, Japan. Scoliidæ, Formicidæ.
1921. THOMAS, C. A., 120 Broad St., Kennett Square, Chester Co., Pa. Aphididæ, Hymenopterous parasites of same.
1915. THOMAS, F. L., State Entomologist, College Station, Texas.
1909. THOMAS, W. A., Bur. Entom., Chadbourn, N. C.
1910. THOMPSON, W. R., European Parsite Lab., Le Mt., Fenouillet, Hyeres, Var. France. Tachinidæ.
1922. TIETZ, HARRISON M., 10326 118th St., Richmond Hill, L. I., New York. Lepidoptera.
1920. TILLYARD, R. J., Cawthron Inst., Nelson, New Zealand. *Fossil Insects.*
1911. TIMBERLAKE, P. H., Citrus Exp. Sta., Riverside, Cal. Encyrtidæ, Syrphidæ, Coccinellidæ.
1923. TISSOT, ARCHIE N., B. & Z. Bldg., Ohio State Univ., Columbus, Ohio. Aphiidæ.
Ch. TITUS, E. G., 1228 Bryan Ave., Salt Lake City, Utah. Apoidea, *Megachilidæ.*
1921. TOWNSEND, M. T., St. John's College, Annapolis, Md.

1924. TURNER, PAUL A., 355 W. Duval St., Germantown, Philadelphia, Pa. Odonata.
1918. TURNER, WM. B., 600 26th St., Sacramento, Cal. Elateridæ.
1908. TURNER, WILLIAM F., 808 Orange St., Macon, Ga. Heteroptera.
1920. UICHANCO, L. B., College of Agr., Los Banos, Coll., Laguna, Phillipine Islands. *Thysanoptera, Psyllidæ*, Aphididæ.
1917. URICH, F. W., 107 Frederick St., Port-of-Spain, Trinidad, British West Indies.
1922. VANCE, ARLO M., U. S. Entom. Lab., Charlottesville, Va.
Ch. VAN DINE, D. L., Central Baragua, Camaguey Province, Cuba.
1917. VAN DUZEE, MILLARD C., 12 Abbotsford Place, Buffalo, N. Y. *Dolichopodidæ.*
1918. VAN ZWALUWENBURG, R. H., H. S. P. A. Exp. Station Honolulu T. H. Elateridæ.
1923. VELLARD, JEHAN A., Instituto de Butanton, C. P. 65, Sao Paulo, Brazil.
Ch. VICKERY, R. A., 10 Court St., Arlington, Mass. Aphididæ.
Ch. VIERECK, H. L., Ento. Branch, Dept. Agr., Ottawa, Can. Hymenoptera.
1913. VORHIES, CHAS. T., University Sta., Tucson, Ariz.
1915. WADE, JOE S., Bur. Entom., Washington, D. C. Coleoptera.
1921. WADLEY, F. M., 126 S. Minneapolis Ave., Wichita, Kan. Aphididæ, Hemiptera.
1924. WAHL, R. O., Agr. Exper. Sta., Potchefstroom, Transvaal, S. Africa.
1918. WAINWRIGHT, COLBRAN J., Daylesford, Handsworth Wood, Birmingham, England. *Tachinidæ.*
1922. WAKELAND, CLAUDE, Entomological Field Station, Parma, Idaho. Eleodiini.
1922. WALKDEN, HERBERT H., 126 S. Minneapolis Ave., Wichita, Kansas.
1923. WALKER, FRED W., Box 505, Univ. Florida, Gainesville, Fla. Orthoptera, Dermaptera.
1923. WALLACE, HUGH E., Univ. Farm, St. Paul, Minn. Pentatomidæ.
1911. WALLIS, J. B., School Board Office, Winnipeg, Canada. Coleoptera; *Haliplidæ, Gyrinidæ, Agabus, Cœlambus.*
1917. WALTON, W. R., Room 5, Bur. Entom., Washington, D. C. Cereal and forage insects.
1913. WATSON, J. R., Agr. Exp. Sta., Gainesville, Fla. *Thysanoptera.*
1916. WEBBER, RAY T., 17 E. Highland Ave., Melrose Highlands, Mass. Diptera.
Ch. WEBSTER, R. L., Agr. College, N. Dak.
1917. WEESE, A. O., Univ. Oklahoma, Norman, Okla. Ecology.
1918. WEHRLE, L. P., Renwick Heights, Ithaca, New York.
1917. WEIGEL, CHARLES A., U. S. Bur. Entom., Washington, D. C. Insects of Ornamentals.
1913. WEISS, HARRY B., 19 N. 7th Ave., Highland Park, New Brunswick, N. J.
1907. WELD, LEWIS H., U. S. Nat. Mus., Washington, D. C. Cynipidæ.
Ch. WELDON, GEO. P., Chaffey, Jr., College Agr., Ontario, Cal. Thrips.
1923. WELLHOUSE, W. H., Agr. Coll., Ames, Iowa.
1923. WELLS, ARTHUR B., Bryn Athyn, Pa. Lepidoptera.
1919. WELLS, B. W., State College, Raleigh, N. C. *Insect Galls.*
1912. WELLS, M. M., 1177 E. 55th St., Chicago, Ill.

1921. WEST, LUTHER S., Dept. Entom., Cornell Univ., Ithaca, N. Y. *Muscoid Diptera.*
1918. WHEDON, ARTHUR D., 1145 3rd St. N., Fargo, N. D. Odonata.
1922. WHEELER, GEORGE C., Dept. Zoology, Syracuse Univ., Syracuse, N. Y. Parasitic Hymenoptera, Ants.
1925. WHITE, CHARLES E., JR., Fernald Hall, Amherst, Mass.
1922. WHITEHEAD, FRED E., Zool. Dept., Idaho Univ., Moscow, Idaho.
1924. WILCOX, JOSEPH, 31 N. 26th St., Corvallis, Ore.
1925. WILCOX, STANLEY D., 21 College St., Springfield, Mass.
1917. WILD, WILLIAM, 359 Walnut St., East Aurora, N. Y. Microlepidoptera.
1921. WILEY, GRACE OLIVE, 2291 Doswell Ave., St. Paul, Minn. Aquatic Hemiptera.
1914. WILLIAMS, R. C., JR., 4537 Pine St., Philadelphia, Pa. Hesperidæ.
1917. WILLIAMS, S. H., Zoology Dept. Univ. Pittsburgh, Pa. Coleoptera, Tenebrionidæ.
1911. WILLIAMSON, WARREN, 257 S. Academy St., Galesburg, Ill.
1923. WILLIS, WARREN J., care of Patent Dept., Westinghouse Electric Co., Lester, Pa.
1923. WILSON, CECIL C., 820 Moro St., Manhattan, Kan. Sphingidæ, Tenebrionidæ.
Ch. WILSON, H. F., Univ. Wis., Madison, Wis.
*Ch. WIRTNER, M., St. Bonifacius, Pa., Cambria Co.
Ch. WOGLUM, R. S., California Fruit Growers Exchange, Los Angeles, Cal.
1908. WOLCOTT, R. H., Univ. of Nebraska, Lincoln, Nebr. Hydracarina.
1914. WOOD, W. B., Dept. Agr., Federal Hort. Board, Washington, D. C.
1924. WOODRUFF, LEWIS B., 14 E. 68th St., New York City. *Membracidæ.*
1913. WOODS, WILLIAM C., Kent School, Kent, Conn. Chrysomelidæ.
1917. WOODWORTH, C. W., Prof. of Entomology, Univ. of Cal., Berkeley, Cal.
1917. WOODWORTH, H. E., Calif. Spray Chemical Co., Watsonville, Calif.
1922. WORTHLEY, HARLAN N., Agr. Exp. Sta., Amherst, Mass. Tachinidæ, *Pepsini.*
Ch. YOTHERS, W. W., Box 491, Orlando, Fla.
1925. YOUNG, MARTIN T., Tallulah, La.
1917. YUASA, HACHIRO, Imperial Univ., Kyoto, Japan.
1917. ZAHROBSKY, V. J., 287 Wood St., Wilmerding, Pa.
1921. ZERNY, HANS, Wien I., Burgring 7, Austria. Heterocera.
1907. ZETEK, JAMES, Box 245, Ancon, Canal Zone. Isoptera.